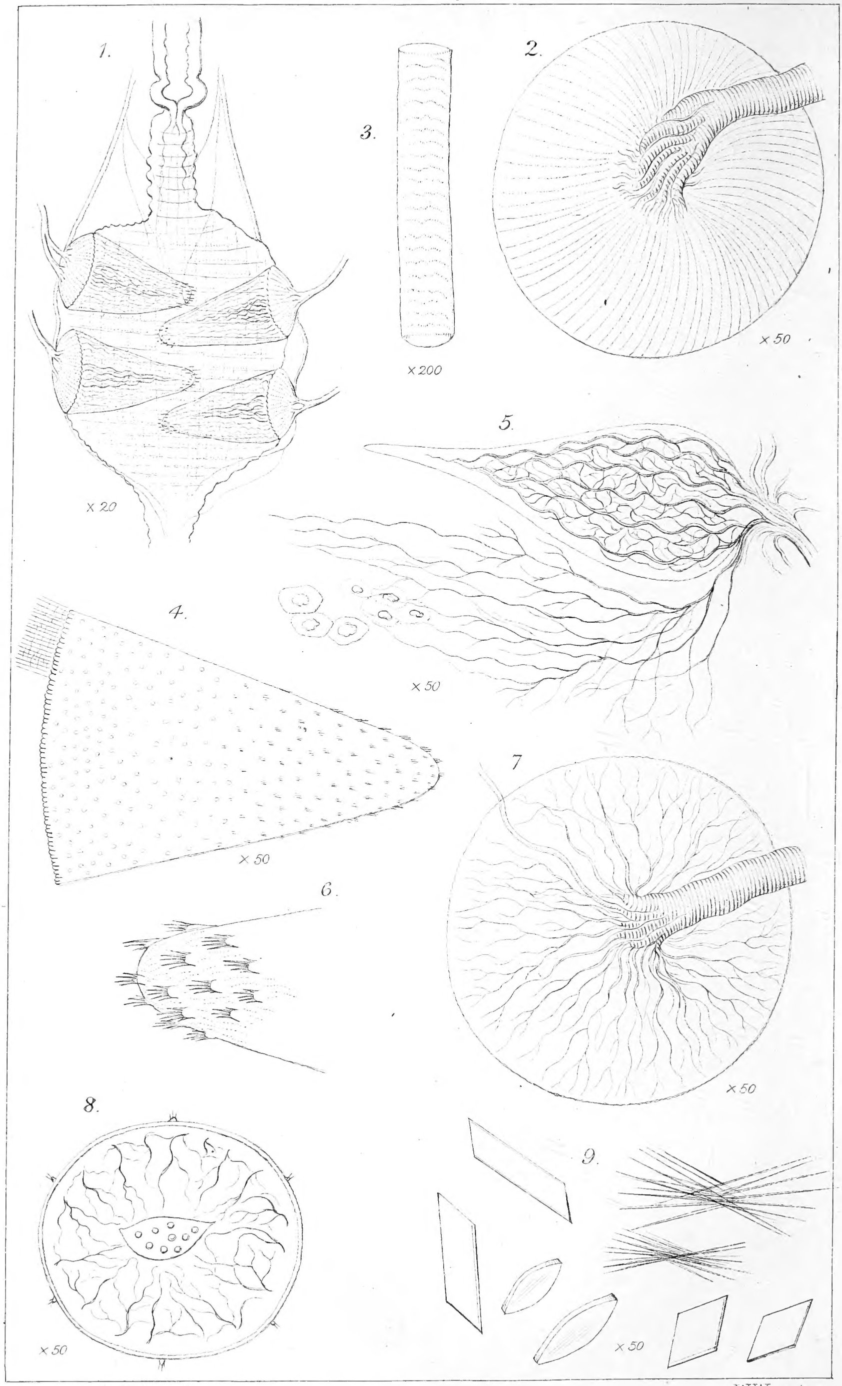

R. Lowne del. Tuffen West sc. W. West imp.

Rectal Papillæ of Blow-fly.

THE MONTHLY

MICROSCOPICAL JOURNAL:

TRANSACTIONS

OF THE

ROYAL MICROSCOPICAL SOCIETY,

AND

RECORD OF HISTOLOGICAL RESEARCH

AT HOME AND ABROAD.

EDITED BY

HENRY LAWSON, M.D., F.R.M.S.,

Assistant Physician to, and Lecturer on Histology in, St. Mary's Hospital.

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THE

MONTHLY MICROSCOPICAL JOURNAL.

JULY 1, 1869.

I.—*On the Rectal Papillæ of the Fly.*

By B. T. Lowne, M.R.C.S.

(*Read before the* Royal Microscopical Society, *May* 12, 1869.)

The organs for which I have retained the name given to them by Weismann, are four in number, situated near the termination of the alimentary canal. They are hollow, conical, glandular organs, about $\frac{1}{30}$th of an inch in length, enclosed in a dilatation of the rectum, and having their bases only external to its cavity. I think I shall be able to show that their function is the excretion of a urinary fluid; I have, however, retained an anatomical name, instead of giving them a physiological one, because its applicability is obvious, and admits of no difference of opinion; it is not a new name; and, lastly, had I called them kidneys, or even renal organs, I should have been comparing them to the totally dissimilar structures found in vertebrates.

Each papilla consists of three parts: an internal central cavity, surrounded by a transparent structureless membrane; around this a hollow cone of gland cells, the secreting portion of the organ, is disposed; and external to this again, a tough transparent cone of membrane, which I shall call the calyx of the papilla, perforated by numerous minute pores, surrounds the whole of that portion of the organ which is internal to the rectum. By a little dexterous manipulation these parts may be separated completely from each other

DESCRIPTION OF PLATE XVIII.

Fig. 1.—The rectum with its papillæ.
„ 2.—Base of a papilla, showing the muscular layer × 75 diam.
„ 3.—A flattened muscular band from the same × 250 diam.
„ 4.—Calyx of the papilla × 75 diam.
„ 5.—Central cavity and portion of the gland structure × 75 diam.
„ 6.—Apex of the calyx × 250 diam.
„ 7.—Base of a papilla, the muscular layer removed, showing the arrangement of the tracheæ.
„ 8.—Transverse section through the middle of a papilla × 75 diam.
„ 9.—Crystals of uric acid from the urinary secretion of the fly.

(Plate XVIII., Figs. 4, 5); or, by hardening the papillæ in chromic acid, sections may be made showing the relations of the parts *in situ*. Fig. 8 represents such a section.

The calyx (Fig. 4) is perforated by about 300 minute pores, each pore being surrounded by a nipple-like projection, which is surmounted by from three to eight minute setæ (Fig. 6). The whole membrane of the calyx becomes thickened towards the apex, where it has a faint, yellow tint; it is near the apex that the nipple-like projections and their setæ are best seen, indeed a casual observer might overlook their presence entirely at the upper portion of the calyx.

The calyx itself is marked by faint reticulations, and its margin is deeply crenated. These are the only indications of structure which it presents, and these seem to point to its being a fibrous membrane, especially as two sets of muscular fibres arise from the crenations of its margin.

These muscular fibres are, first, a set from the muscular coat of the rectum, and, secondly, a layer of converging fibres which cover the whole base of the papilla to within a very short distance of its centre, and which apparently end in the edge of the membrane forming the boundary of the central cavity, although from the extreme transparency of this membrane it is nearly impossible to be certain of their insertion (Fig. 2).

Each papilla is supplied with air by a large tracheal vessel from the last abdominal spiracle, which divides into several—generally five or six—large trunks before entering the papilla. The tracheæ of the papilla may be divided into two sets as soon as they enter the base of the organ; first, from twenty to thirty radiating lateral branches which run to the edge of the base (Fig. 7), and then pass over the outer surface of the glandular structure to the apex of the cone, giving off numerous branches, which anastomose freely, and form a fine reticulation around the gland cells, the larger branches running directly towards the central cavity, and forming loops by anastomosing with other similar vessels (Fig. 8).

The second set are the terminations of the main tracheæ: after giving off the lateral branches these run directly into the central cavity, where they become tortuous, and anastomose with each other, giving off comparatively few small vessels in proportion to their size, and forming a network which fills the central cavity, but none of their branches pierce its investing membrane anywhere. Fig. 5 represents the central cavity with its tracheæ, with a small portion of the lateral branches and their terminations amongst the glandular structure.

Each papilla receives two or three nerve filaments from one of a pair of nerves given off at the termination of the ventral cord, which are distributed to the muscular coat of the rectum; a few

very small filaments appear to accompany the tracheæ into the central cavity.

The gland cells are large—about $\frac{1}{300}$th of an inch in diameter—and slightly angular by mutual pressure; each contains a granular nucleus about one-third the diameter of the cell.

In order to understand the functions of these organs it will be necessary to investigate briefly the structure of that portion of the alimentary canal which encloses them. About two lines above the anal orifice a sphincter, or rather a kind of muscular valve, closes the intestine (Fig. 1, *a*). A little below this the rectum becomes much dilated, and its muscular coat correspondingly attenuated; when the insect first emerges from the pupa case this dilatation is filled with a semi-solid mass of uric acid. I have never found any of this substance above the valve I have just described—an important fact in relation to the function of the rectal papillæ.

There is nothing new in the fact that insects excrete uric acid; figures of crystals of this substance from the excrement of the clothes-moth and stag-beetle will be found in the 'Micrographic Dictionary.' I have given figures of several forms from that of the fly (Fig. 9); the only question is by what structure is this substance eliminated.

There are only two gland structures which open into the alimentary canal of the fly—the rectal papillæ and the malpighian or liver-tubes; these latter, beside opening into the intestines more than two lines above the valve I have described, contain cells which from their contents—oil-globules and yellow pigment—are unmistakably liver-cells. I have compared these carefully with cells from the liver of the bullock, and could see no difference except that those of the latter animal contained more and larger oil-globules than are present in the liver-cells of the fly. Hence I conclude that we must not look to the malpighian tubes for the origin of the urinary secretion.

On the other hand, the structure of the rectal papillæ is just such as we might expect to find in a renal organ. If I am right in my belief that the central cavity is continuous with the visceral cavity, it affords a mean of bringing the circulating fluid into almost immediate contact with the secreting cells, a fine structureless membrane only, being interposed—still further I believe I am justified in asserting that the circulating fluid is expelled from, and a fresh supply is drawn into, the central cavity by a rhythmic muscular act.

In the female fly the rectal papillæ lie fortunately between the second and third rings of the ovipositor when that organ is exserted, where it is sufficiently transparent to allow of the papillæ being seen during life. I have repeatedly observed a movement of the kind I have described. I believe this is the explanation of the

radiating bands of muscle at the base of the papillæ; they probably open the central cavity, and at the same time press upon the contents of the papillæ, and, assisted by the muscular wall of the rectum, which contracts at the same instant, they not only expel the contents of the central cavity, but also press the secreted fluid through the minute pores in the calyx into the cavity of the rectum; the central cavity is probably refilled by the elasticity of the calyx itself.

There is no trace of these organs in the maggot, and at present I cannot state at what precise period they first appear in the pupa, but as soon as the embryo fly, if I may be allowed the expression, has become so far developed that its principal parts may be easily recognized, about the end of the second or the beginning of the third week of the pupa state, the calices of these organs are already formed and filled with gland-cells, larger than those in the adult fly, but otherwise similar; the tracheal vessels are quite rudimentary and very transparent, and the calices themselves are striated coarsely, but exhibit the nipple-like pores so characteristic of them. No muscular fibres are then distinctly traceable, but their position is marked by the presence of rapidly growing cells.

With regard to the urinary secretion itself, that passed by the insect when it first emerges from the pupa case is a semi-solid mass of nearly pure uric acid; that passed afterwards is a turbid fluid, sometimes almost clear, and very irritating when applied to any tender part of the skin: this fluid deposits an abundance of crystals of uric acid when acidulated with hydrochloric or nitric acids. Fig. 9 represents the principal forms of these crystals. I believe the acid is held in solution by ammonia, but of this I am not certain. The excrement of the fly when heated over a lamp gives off a strong urinary smell.

II.—*On the Diatom Prism, and the True Form of Diatom Markings.* By the Rev. J. B. Reade, M.A., F.R.S., President of the Royal Microscopical Society.

(*Read before the* Royal Microscopical Society, *June* 9, 1869.)

The pages of our Transactions, from the commencement of our Society to the present time, bear ample evidence of the interest which is taken in the structure of the Diatom-valve, and of the Protean aspects which different observers have confidently recorded under different methods of illumination. In venturing to propose a new method of illumination and to describe new results, I must be permitted to copy the confidence of those who have preceded me, and to say that the usual methods of illumination are wrong in principle, and the consequent descriptions of the form of Diatom Markings are wrong in detail. But this, says one of my friends, is "a startler," and we all have to go to school again. I can only reply, that I have never left school, and the new lesson I have just learnt is not one of least interest, for it is admitted by those who have bestowed no unworthy labour on the minute structure of the diatom-valve, that the correct exposition of the structure involves a question quite as important, perhaps, as any we have to encounter in the whole course of vegetable physiology. It was only when I was imposed upon by lines, *i.e.* when I was taught to believe that on the valve of *P. angulatum*, for instance, there are sets of three lines in the direction of the sides of an equilateral triangle, and formed by probably elevated ridges, that I proposed to obtain their shadows, not by a circle of light, as in the common "stop lens," but by three separate points of light of proper intensity in the kettledrum, to be placed by the revolution of the sub-stage at right-angles to the lines to be resolved; and if this were the true structure, the principle of illumination is correct. The result also appeared to be satisfactory. The lines of shadows were readily made out, with the due arrangement of hexagonal markings, formed by the crossing of two equilateral triangles of these shadow-lines; but, after all, so far as the eye was concerned, there was only an illustration of Berkeley's theory of "No matter,"—shadow, without the substance. I have, however, at last seen the substance, and an exact knowledge of its form renders it absolutely necessary most materially to modify the mode of illumination.

I will state at once—and I hope to prove to the Society, as I have proved to others, the truth of what I affirm—that the outer surfaces of the two valves of diatoms in the family Naviculeæ are covered with rows of siliceous hemispheres, inclined at varying angles both to each other and to the longitudinal division of the

valve. Hence, in scientific descriptions, the terms "striation and lineation" are no longer admissible, and the books we now have in our hands are not a mirror held up to nature, in which the members of this family could recognize themselves, for "striæ and lines" are just as little applicable to the rows of hemispheres on the surface of a diatom-valve as they would be to a hayfield with its rows of haycocks.

Further, with reference to structure, a vertical section of *P. Quadratum* reveals the fact that the siliceous hemispheres on the outer surfaces have corresponding hemispheres on the inner surfaces; in fact, we have perfect spheres of silica set equatorially in the siliceous tissue of the valve. That such arrangement is the law of the structure, does not admit of doubt. The silica is the solid material round which the carbonaceous portion of the living cell gathers, and thus it has its counterpart in every cell of every plant in the vegetable kingdom, for the varying solid material of the cells of plants is as necessary as the carbonaceous material for enabling them to perform their proper functions in the economy of vegetation. In this respect it may be said to correspond with the osseous system in animals. As a very different arrangement of the same solid materials is invariably found in the mineral kingdom, we cannot but recognize the action of different laws in the formation of the crystal and of the cell; for, if the soluble silica obeyed the same law during its solidification in the latter case as in the former, we should have examples of rock-crystal in the cell instead of a siliceous cell-wall. This consideration ought to be borne in mind when we treat of the important subject of cell-formation. Protoplasm alone is not to Nature's liking.

As I was a pupil, I may almost say a friend, of Ehrenberg, who named for me the Xanthidia which I found in flint, I have been for a long time unable to recognize the entire validity of the arguments which exclude the Diatomaceæ from the animal kingdom. But when I now see the form and arrangement of the silica on the cell-wall of the diatom to be so exactly like its form—and its arrangement in consecutive corpuscles—on the stomata of many plants that I have examined, and so exceedingly unlike any secretion of silica in any other kingdom than the vegetable, I find no difficulty whatever in placing the Diatomaceæ among the unicellular algæ.

On viewing the surface of different diatom-valves, we find a great difference in the diameter of the hemispheres, and in their distance from each other. We are told, popularly, and in sufficiently vague language, so far as structure is concerned, that the "*striæ*" range between about 30 and 100 in $\frac{1}{1000}$th of an inch, and, to adduce an example, that the striæ of *P. strigilis* are much closer than those of *P. formosum*—a statement which gives no idea of the fact that the diameters of their hemispheres are the

same. Doubtless it would be more accurate to give the number of the hemispheres and the measure of the space between them, or the ratios of the diameter and the interval.

In my own microscope, with Ross's $\frac{1}{12}$th and a double D eye-piece, the diameter of the field of view at the distance of the stage from the eye is 12 inches, and this space represents the magnified image of $\frac{1}{1000}$th of a inch, on a micrometer-slide ruled by Mr. Waterhouse. The magnifying power is therefore 12,000 linear. Using this arrangement, *P. Quadratum* has 40 hemispheres and 40 intervals in the diameter of the field, *i.e.* in 12 inches, which cover $\frac{1}{1000}$th of an inch on the micrometer-slide, and as each interval is equal to a radius of a hemisphere, the magnified diameter of each hemisphere covers $\frac{2}{10}$ths, and the interval $\frac{1}{10}$th of an inch. Therefore, the real diameter of the hemispheres is $\frac{1}{60000}$th, and of each interval $\frac{1}{120000}$th of an inch. The rows of hemispheres cross each other at an angle of 60°, as in *P. angulatum*, and are therefore arranged in the order of the sides of an equilateral triangle. Hence, under the illusion of the common methods of illumination, which deal with shadows only, and under deep powers, the markings of these diatoms are described and figured as hexagons, with the sides and centre light and dark, or *vice versâ*, and PHOTOGRAPHY stands by as an attesting witness. But this illusion arises from causing either the illuminated or the shaded portions of the hemispheres to run into each other, and so to form hexagons with either dark or light centres.

In a valuable paper by Dr. Wallich, "On the Development and Structure of the Diatom-valve," communicated to the Microscopical Society in March, 1860, it is stated that "in *P. formosum* there exists good evidence to prove that the interlinear spaces are occupied by elevated rhomboidal papillæ, which present facetted surfaces, whereas in *P. balticum*, instead of rhomboidal elevations, we have four-sided flattened pyramids, presenting, as in the former case, four sets of lines, of which those bounding the spaces, and not crossing them, are the predominant ones." No one will be more pleased than Dr. Wallich with the very different, but more truthful representation of these valves when illuminated by the *diatom-prism* which I will presently describe. In both valves we have rows of siliceous hemispheres. Those in *P. formosum* are at right-angles to each other, and meet the longitudinal division of the valve at an angle of 45°. In one direction there are 24 hemispheres and intervals in the 12-inch diameter of the field already described, and in the direction at right-angles to it there are 30 diameters and intervals, so that the rows of equal hemispheres are rather closer together in one direction than in the other. Here, under the magnifying power of 12,000 linear, one hemisphere and interval occupy half-an-inch, the apparent diameter of the hemi-

sphere being $\frac{3}{10}$ths, and of the interval $\frac{2}{10}$ths of an inch; this, of course, makes the real diameter of the hemisphere $\frac{1}{40000}$th of an inch, and therefore, with *strigilis*, among the largest in the range of valvular structure. The "stout costæ" of Pinnularia major also follow the law of structure, and consist of very closely-packed spheres. When Mr. Sheppard, of Canterbury, saw these and other diatoms under the new illumination, he felt obliged to say that the microscope makes a new start on the Queen's birthday, 1869; and a young friend of mine, under fourteen years of age, exclaimed, when he saw the *formosum*, that "it looked like a plate of marbles." This, at all events, may be adduced as the evidence of an unprejudiced witness to the truthfulness of my story. *Pleurosigma balticum*, which we have all looked upon as presenting four-sided flattened pyramids, as described by Dr. Wallich, follows the same law of cell-formation as its congeners, the only modification being the cropping out of a rather larger portion of the sphere above the surface of the valve.

It is amusing now to read of ingenious modes of playing with the illuminating rays, so that the eye, fortified by a little previous theory, may see at will, either elevations or depressions, triangular, quadrangular, or hexagonal dots, with rhomboids, pyramids, or spheres. But *Truth* is not so many-faced as this, and it is, therefore, very satisfactory to find at the conclusion of Dr. Wallich's paper in the Transactions, that the editors have added an important note, which more than justifies my confidence in the accuracy of my descriptions. It is as follows:—"In the discussion which followed the reading of Dr. Wallich's paper, Mr. Wenham stated that, with an object-glass of his own construction, having a focal distance of about $\frac{1}{50}$th of an inch and a large aperture, he had ascertained, beyond doubt, that in *Pleurosigma angulatum*, and some others, the valves are composed wholly of spherical particles of silex, possessing high refractive properties. And he showed how all the various optical appearances in the valves of the Diatomaceæ might be reconciled with the supposition that their structure was universally the same." Mr. Wenham will be glad to learn that, while the true valvular structure was revealed to him by the $\frac{1}{50}$th of an inch, a power which few hands besides his own can make, and few observers can ever hope to possess, the diatom-prism, as an educational adjunct, will enable all observers to see the exquisite structure of the coarser valves, for even a $\frac{2}{3}$rds of an inch by Wray, with the D and double D eye-piece, shows "the plate of marbles" on *P. formosum* with abundant light and perfect achromatism.

It is needless to observe that deeper powers are required when attacking a valve like *N. rhomboides*. Here the $\frac{1}{12}$th is used, and I am sure that the exquisite beauty of this valve will be a treat to critical eyes. The acknowledged difficulty of resolving it arises

from the extreme closeness of the very minute hemispheres in the longitudinal rows. Round the valve, and forming an elegant border, are three rows of beads or hemispheres gradually decreasing in size—then, on the semi-diameter of the valve through the centre, 14 rows of much smaller beads, numbering at least 80 in $\frac{1}{1000}$th of an inch—and then the two "median lines," which consist of hemispheres as large as those in the outer row of the border. In the centre of the valve the boss or *umbilicus* pushes out the adjacent beads of the median rows into an oval form. Powell's immersion lens would bear with admirable effect upon this exquisite object, and bring out the wondrous structure which, without the aid of the microscope, must have remained among the invisible things of Him who created all things. This lens would no doubt show also an exactly similar structure on the still more difficult valve *Amphipleura acus*, the shadows of the beads being already seen as apparent lines.

Such and so satisfactory is the work of the diatom-prism, which has made the microscope, old observer as I am, quite a new instrument *to me*. This is evident from the curious coincidence of my having given such a different description of *rhomboides* at the last meeting of the Society. In then describing the markings as brought out by a supposed improvement of the double hemispherical condenser, I used the language of the craft, and spoke of "dots as black as jet;" but this mere silhouette representation of *rhomboides*, an unnatural distortion of light and shade, I never wish to see again.

A single sentence will be sufficient to describe the diatom-prism illumination. I place *an equilateral* prism below the stage of the microscope, and the light, either of the sun or of a lamp, after being totally reflected, is made to fall obliquely on the valve to be examined. The light of a lamp is condensed in parallel rays by means of a bull's-eye lens. This is all. But why never used! Is it possible that, without making the trial, a supposed deficiency of the power of a few parallel rays could prove a bar to the experiment? Yet it would almost seem as if such were the case, since Newton, Chevalier, Amici, Brewster, and Abraham have suggested different modes of obtaining condensed and convergent reflected light, and their prisms have frequently formed adjuncts for microscopical examination. But, be this as it may, the fact remains that we are still without any authoritative recommendation to adopt the method I have described. Its advantages, however, are great and obvious. I have no longer two suns in my firmament, shining at right-angles to each other, but one source of proper light properly placed; and therefore, instead of the false appearance of lines and striæ, rectilineal and oblique under low powers, and of hexagons and other fancies, under high powers. I see what really does exist, *viz.* a series of beautiful hemispheres placed in their due order on

the siliceous tissue of the valve. The kettledrum with its double pencil of light is therefore, *quoad hoc*, a thing of the past. If the hemisphere on the stage were really the size which our powers make it, nearly half an inch in diameter, it would be seen by unassisted vision, and we should smile at a supposed necessity of forming its shadow by two sources of light, just as an artist would smile if he were advised to have two windows in his studio at right-angles to each other, for the more artistic illumination of his sitter. The moon, as shown by the sun's illumination, is a fair illustration of diatom-illumination. Light, virtually parallel, falling obliquely on one side only of its mountains and craters, produces *natural* light and shade. Any other arrangement would fail, and for this reason right-angled apertures either with the kettledrum or the prism lead to illusions. The kettledrum, however, with one aperture properly placed, is still a serviceable condenser, and brings out the hemispheres remarkably well. Still, refracted light has not the power and purity of reflected light; and converging rays, whether reflected from a convex prism or refracted through a lens, must yield the palm to parallel light, which is obtained by Newton's plane prism as from the sun. The truth of this remark will be obvious if we place the smaller hemisphere of the kettledrum at right angles to its present position, and use it for obtaining condensed, reflected, and convergent rays from its flat surface, as proposed by Brewster. In this case, the object, being in a cone of converging rays, is virtually under the influence of more than one source of light, and its character is lost amid the intense illumination. It would be easy, by means of a double concave lens placed within the focus of the converging cone, to produce an intense beam of parallel light without any assistance from the bull's-eye lens, and this might enable us to detect more accurately the structure of such unapproachable fineness as obtains in *Aphipleura pellucida.* The direct light of the sun, when reflected by the plane prism, would thus be represented by a very close approximation.

In the mechanical adjustment of the prism to the sub-stage, I would suggest a cradle above a ball-and-socket joint, as prisms are often mounted, with the addition of a jointed arm, as used for the extension of the mirror of our microscopes sideways, and, if necessary, a clamping-screw to keep the prism in position. At present, I fix the prism on the sub-stage with an india-rubber band. All that is required is the power of turning the prism on its axis, and also of placing it over any diameter or any chord of the sub-stage. In the latter position, the prism lying over a chord from 30° east of the vertex of the stage to 30° west of south, and its face slightly inclined to the upper stage, very effective obliquity is obtained. The lamp, of course, stands to the west. We must rotate the valve by the circular motion of the upper stage, till the hemi-

spheres are not obscured by the parallel lines of their own shadows. When they reach their proper place they seem to start into existence, and the degree of elevation is conferred *per saltum*. By this perfect command over its movements, the "diatom-prism" (thus named from its first application) will meet every requirement for oblique, direct, and dark-ground illumination, while its simplicity and independence of harness, in the shape of diaphragms or stops, is a chief characteristic. The light being nearly parallel, the prism may be moved, by the rackwork adjustment of the sub-stage, to a considerable distance below the object without materially weakening the illumination—and the slight diminution of light thus obtained is advantageous when using low powers.

It is impossible to avoid noticing the remarkable stereoscopic effect of this parallel reflected light. On a Barbadoes slide, for instance, the objects are seen under an inch power and on a dark ground in very striking relief; and the same effect is remarkably visible when viewing the proboscis of the blow-fly on a light ground. The peculiar character of muscular fibre is also well displayed, new beauty is seen in the Podura scale, and infusoria and portions of insects may be examined with additional interest.

It seems to be owing to this stereoscopic effect of parallel light and natural shadows, that the hemispheres of diatom-valves are seen beyond all doubt as elevations. We seem to be looking at an opaque body illuminated from above, and the appearance in the microscope is exactly similar to a model, made to scale, in plaster of Paris. On the other hand, when we have anything approaching to depressions, as in the markings of *Triceratium* and *Isthmia*, these depressions are, as it were, palpably felt. The hexagonal markings in *Triceratium* are of special interest. At every angle of the hexagon there is a hemisphere of larger size, and smaller hemispheres, in contact with each other, form the sides, so that it is questionable whether the depression is deeper than the radius of the hemispheres themselves. A similar inquiry also presents itself when viewing the irregular though somewhat circular markings formed by an arrangement of small hemispheres on the surface of *Isthmia*.

I felt unwilling that the present session should close without giving some account of my observations to those who have more leisure than myself for pursuing these interesting researches. That the hemispheres which Mr. Wenham speaks of generally, and Mr. Hogg figures in the case of *P. formosum*, are such as I have described is, I hope, satisfactorily proved. There they are. I can number them, I can weigh them, I can measure them—and number, measure, and weight may be justly represented as the three rectangular co-ordinates of all accurate knowledge of matter.

III.—*Observations on the Recent Investigations into the Supposed Cholera Fungus.* By the Rev. M. J. Berkeley, M.A., F.L.S.

The observations which were recently published by Dr. Hallier on the supposed origin of Cholera from Parasitic Fungi, were put forth with such confidence, and with such intimate acquaintance, as it seemed, with lower cryptogamic forms, that they excited far more interest in this country than they were entitled to, and, in consequence, were lauded in our journals as strictly logical, either at second-hand, or from a very imperfect acquaintance with the objects in question, insomuch that it was deemed imperative on the part of the medical officers of the Privy Council to submit the matter to a complete investigation.

Two of the most promising candidates for employment in the British and Indian armies were therefore selected to examine the subject accurately, and to this end they were first put in connection with the best authorities in this country and on the Continent, including Dr. Hallier himself, previous to setting out for India, where they are now carrying on their investigations. Three reports on the subject were given in the 'Lancet' in the early part of the present year, which in a short compass comprise the results of their labours up to their departure for India.

To a person well versed in fungi, Dr. Hallier's observations appeared too vague and undecided to inspire much confidence, and the more so as it was clear that he had very loose notions as to the real characters of genera. His leading point, that he had succeeded by a series of changes in producing *Urocystis occulta* from cholera dejections—a fungus which might possibly occur in the rice plant —was at once invalidated by the fact that what he figures as that species was totally different from the plant of Wallroth, by whom it was first described as growing on rye, a fact which was easily ascertained, as good specimens of the fungus in question were in the hands of fungologists as published by Rabenhorst. It became, however, matter of interest to ascertain what fungi really grow upon the rice plant; and accordingly pains have been taken by Mr. Thwaites, the acute Director of the Botanical Garden at Peradeniya in Ceylon, than whom few have a more intimate acquaintance with cryptogamic plants, to acquire every possible information both in India and Ceylon. All his inquiries, however, have failed to detect a single fungus on the rice plant, even distantly allied to the Urocystis (*Polycystis Auct.*): indeed the only fungus which has been detected is a little species of Cladosporium, differing from the universally diffused *Cladosporium herbarum*, and which, like that, is clearly an aftergrowth, and not a true parasite. Amongst

some 7000 numbers of fungi from North and South Carolina not a single one occurs on rice.

His argument, moreover, as to the eastern origin of Tilletia, as though it were confined to wheat, was entirely overthrown by the fact that it occurs on decidedly European grasses, from which it might as easily be derived to wheat, as from wheat to these grasses, and that a distinct species occurs on wheat in the United States, which is not known in any other country.

His experiments, moreover, were conducted in such a way as to make it almost impossible to say whether any particular form was derived from some especial spore, without which it is clearly premature to arrive at any plausible conclusion.

There is, indeed, no doubt that from the spores of a particular fungus, under different circumstances very different forms of fructification may occur, a fact with which every mycologist is familiar; but these forms are in general mere modifications, as was shown in the 'Journal of the Linnean Society' in an article on the Fungus-foot of India; while some, as the so-called Torulæ, have no title to the name of true fructification at all, but are rather analogous to gemmæ, as is the case with the so-called yeast plant. It is also quite true that in the same species we may have two or more distinct forms of fructification; and few matters are more interesting than to trace out the connection of many so-called genera with the more normal form, as has been done so successfully by the Messrs. Tulasne; but this is a totally different thing from the transformation of one genus into another. Indeed there is not a single case indicated by Dr. Hallier which is entitled to the same praise as the numerous cases demonstrated by those authors. An attentive perusal of the report of what Drs. Cunningham and Lewis saw at De Bary's, and the instructions derived from him, as well as that of their conference with Dr. Hallier, will be quite sufficient to make us receive Dr. Hallier's views with much less attention than they have attracted in certain quarters.

It is quite possible to follow the development of a single spore, as is indicated in the article Yeast in the 'Encyclopædia of Agriculture,'* though this has been called in question by De Bary. It is true that if certain minute bodies be insolated from yeast, we may not always be certain that they are not derived from some quarter extraneous to the yeast itself; but if we get them to fructify, we shall at least have some certain information as to the different phases which have been assumed by a particular fungus, and it will be found that the medium in which the fructification takes place will make an immense difference. If we repeatedly

* The same method was pursued to ascertain the real nature of the little Sclerotium which is so common in onions, as indicated in an article in the 'Journal of the Royal Horticultural Society of London.'

obtain the same result, and if this corresponds with what is exhibited by rougher experiments, we shall be pretty certain that we have indeed arrived at the true nature of the yeast plant.

What is really wanted at present is to trace accurately the development of those obscure bodies which are the first signs of vegetable life in infusions or in substances in an early stage of decomposition. No one seems to know exactly what the little variously-coloured gelatinous bodies are which occur in paste and other moist vegetable substances, and amongst them the so-called blood-rain; and the same may be said of what are variously called Bacteria, Vibrios, or Leptothrix, and which come in close succession to the monads. The investigation is certainly one of great, but perhaps not insurmountable difficulty, and might be carried on in closed cells containing a drop of some suitable fluid surrounded with air. When examined *en masse*, it is almost impossible to say with any certainty that one form is derived from the other, however probable it may be that this is actually the case.

Our young commissioners were very properly placed in communication with Professor Huxley, who has paid especial attention to this interesting matter. When we had an opportunity of examining his preparations, it must be confessed, under very unfavourable circumstances as regards illumination, we saw sufficient to hope that he would continue his investigations, and we think that he has exercised a very wise discretion in not publishing his observations too hastily.* We have long thought that the subject is one of the highest importance as regards many sanitary questions, and, if thoroughly worked out without the slightest tendency to draw conclusions in any especial direction, we feel confident that much good would be accomplished.

The preparations which were given by Dr. Hallier as to the connection of fungi with scarlet fever, &c., which we had an opportunity of examining, proved absolutely nothing, as far as we could see; and as regards the emanation of fungous spores from drains or other localities containing putrefying matter, which we are not inclined for a moment to deny, we should require some tangible proof before we arrive at the conclusion that they have anything to do with disease.

It would be mere folly to blind the eyes to the experiments of Pouchet, Child, Bennett, and others, as to what is called the Atmospheric Germ theory; but, whatever may be the origin of the minute bodies in question, whether from pre-existent spores or the fortuitous concourse of chemical and other energetic forces, it is

* The cell-forms observed by Rainey and others in various viscous substances prove but very little, unless it could be shown that they were real cells with a wall composed of cellulose, and nitrogenous contents. That cells may originate in organizable matter is clear from the mode in which spores are formed in the asci of ascigerous fungi.

a matter of immense importance to ascertain whether they have any real connection with disease, and it is at once obvious that the question as to their origin becomes eminently essential. If these bodies can arise from accidental momenta, and if at the same time they have any connection with hospital gangrene, erysipelas, or contagious fevers, we need not be surprised at the occasional insolated origin of such diseases, from whence they may spread in definite directions.* At present there is no proof whatever that different fevers owe their origin to different parasitic fungi, or that especial forms of the same common species appear constantly in the several forms of fever, a circumstance for which there is better evidence perhaps as regards certain skin diseases. It is, however, unfortunate that the writers on these subjects are seldom persons who are well acquainted with fungi. We may, as an instance, adduce the assertion in Dr. Bennett's important lecture before the College of Surgeons of Edinburgh, 17th January, 1868, that the genus Aspergillus is characterized by "capsules containing numerous globular seeds," a character which, to a certain extent, would apply to Mucor, the genus Aspergillus however bearing like Penicillium necklaces of spores, but seated on an ovate or globular base of rather complicated structure.†

We shall wait with much interest for the complete report from India, which, from the intelligence of the young men engaged in the inquiry, will, we are sure, justify the selection which has been made by the Privy Council.

IV.—*On the Correlation of Microscopic Physiology and Microscopic Physics.* By John Browning, F.R.A.S.

At a late meeting of the Royal Microscopical Society I listened with great interest to a paper kindly written for the Society by Dr. Beale, on Protoplasm.

On the physiological details in that paper I shall not attempt

* It appears from experiments made by Mr. Hoffman at the Marine Infirmary at Margate, that diseases such as Pyemia, which occasionally spread from bed to bed, may be insolated by the use of iodine placed under the bed and bedclothes.

† The assertion in the same lecture, p. 24, that Mr. Busk found spores of *Uredo segetum* in choleraic dejections is incorrect. What was really found was spores of the common Bunt (*Tilletia caries*). The spores of the Uredo, or rather Ustilago, are all blown away by the wind long before the seed is ripe, and never accompany the grain into the miller's hopper.

I may take this opportunity of calling attention to the fact, which is not generally recognized, that Homer was perfectly aware of the origin of the larvæ which appear in putrefying carcasses. See 'Iliad,' xix., v. 23, where he says that flies generate the worms.

to offer an opinion. But in the paper, and more particularly in the discussion which followed the reading of the paper, Dr. Beale made requent references to various branches of physics.

The tendency of those remarks, if I understood Dr. Beale correctly, was to deny that any close relationship exists between microscopic physiology and microscopic physics. It seems to me desirable to state some of the leading facts that can be adduced in proof of such a relationship.

Before proceeding to the parallels I wish to draw between microscopic physiology and microscopic physics, I must refer, briefly, to a point which was raised in the discussion that took place after Dr. Beale's paper was read, as to the instantaneous death of cells. Dr. Beale evidently supported this hypothesis.

The word instantaneous is often used with respect to motions which take an appreciable amount of time. By the aid of the electric chronograph, astronomers now register the passage of time to hundredths of a second.

The velocity of light is nearly 200,000 miles a second. Its passage across a single cell would require, then, a certain amount of time to complete it. Reasoning from analogy, we are forced to conclude that whenever a change occurs in any matter, *time* will be required for the change to be completed.

But Dr. Beale laid the greatest stress on the motion of mucus as necessitating the assumption of the action of a vital force. It seems to me that a parallel case of motion can be found in molecular physics.

When a soft iron rod is powerfully magnetized by means of a voltaic battery, it expands. On the connection with the battery being broken, it again contracts.

This action, by a proper arrangement of the voltaic battery, can be easily made automatic, and would then go on until the power of the electricity was exhausted. During the whole time, the iron bar would give out a distinctly audible sound at every expansion and contraction.

Faraday tried this experiment, and failed to detect the expansion. We owe the knowledge of the fact to Professor Tyndall, who made the discovery by using more delicate apparatus. In all probability Faraday would have succeeded if he had used a powerful microscope, furnished with a micrometer to measure the length of the bar. I think it is much to be regretted that physicists do not have more frequent recourse to the microscope. Mr. Sorby has made many discoveries by applying the microscope in a most ingenious manner to the investigation of the structures of iron and steel, iron ores, and meteorites.

Of another kind of motion, analogous to ciliary motion, my friend, Mr. Chandler Roberts, has kindly shown an example; in-

deed, he contrived one form of this experiment for the purpose of illustrating my remarks in this paper.

It consists of a strip of the metal palladium in water. When contact is made with a small galvanic battery these strips of metal will roll themselves up into spiral coils. Some will vibrate, some will actually move forward with a motion closely resembling that of a common earth-worm. On the connection with the poles of the battery being reversed, all the movements will take place in a contrary direction. These strange movements are caused by the metallic palladium absorbing the hydrogen which would otherwise be given off by the decomposition of the water. This hydrogen is expelled when the poles of the battery are reversed, or it unites with the oxygen which is now produced, and together they form water.

This arrangement can also be made automatic. Yet this palladium will in time lose the property of expanding and contracting on being connected with the battery, because its molecules have undergone a great change in their arrangement, not, I presume, because the palladium has lost its *vital force.*

Fortunately we are not in doubt as to what change occurs, for Mr. Roberts, after repeatedly charging a palladium wire with 600 times its own volume of hydrogen, and then expelling it, examined the wire with a microscope and found it torn and rent asunder.

This motion is due to physical causes over which we have complete control; but, apart from such cases as this, we have good reasons for believing that all forces are modes of motion.

If we take a powerful galvanic battery, we find the chemical action changed into, or producing electricity. Cause this electricity to pass through a wire and the wire will become hot; let it pass through a smaller wire, that is, interpose a greater resistance to its passage, and the wire will become white hot and give out light. By allowing the heat to fall on a thermo-pile, we can again convert it into electricity.

Light has long been considered as due to the rapid undulations of ether. Heat and electricity Prof. Tyndall and Mr. Brooke have taught us to regard as modes of motion. On this hypothesis the correlation of the physical forces becomes an exceedingly simple matter to understand.

When we throw a spectrum on a screen, if we use a delicate thermometer, we find that the greatest heat exists beyond the visible rays of the red end of the spectrum. Dr. Tyndall has shown these heat rays may be separated from the light rays, and various substances may be set on fire by such rays brought to a focus by a lens, the substances becoming heated and lighted without contact with other matter in the dark, the effect being a result of *invisible motion.* This fact would probably be disposed of as *inconceivable* by anyone unacquainted with physics.

There are probably some grounds for believing that the particles or molecules in magnets are always in motion. Mr. Wenham once told me that he had seen a cavity in a crystal partially filled with a fluid, and for several years this fluid had been unceasingly in motion, although completely shut off from the surrounding atmosphere.

Motion, then, is not peculiar to life, and we shall be brought at last to the single distinction—reproduction.

The difficulty here would be insuperable if we were compelled to accept the hypothesis that life is transmitted from one organism to another. But this hypothesis is no longer generally accepted. Prof. Owen, who has been until recently opposed to such views, has at length accepted the hypothesis of spontaneous generation.

An article in 'Scientific Opinion,' April 28, thus tersely states the case in favour of this hypothesis:—"If when we expose an organic infusion to the air it soon becomes peopled by myriads of animal and vegetable forms, either these have been formed spontaneously, or their ova have been carried to the infusion through the atmosphere. Now the latter alternative involves an hypothesis difficult to prove, and as yet far enough from demonstration. It insists on the supposition that the air is charged with the germs of the animals and plants. But is this the case? There seems to be but very little testimony in its favour. M. Pasteur asserts that it is so. But Bennett, Pouchet, and several others skilled in the use of the microscope, have failed absolutely to detect these ubiquitous germs. Whence, then, are they derived, if not from the decomposing organic matter? Many of those who are still sceptical as to heterogeny, admit that they have watched the conversion of bacteria into fungoid growths; and some have even alleged that they have witnessed the conversion of bacteria into infusoria. Surely these are as difficult statements to digest as the theory of spontaneous generation."

Chemists were wont until very recently to divide all substances into organic and inorganic. Even then an account had to be given of the compounds in salts formed by the union of metals with organic acids. Now in the latest works we find a list of substances called organo-metallic bodies, in which the metals zinc, tin, cadmium, mercury, magnesium, aluminium, and glucinum are directly combined with organic radicles. In these compounds zinc may be found as a constituent of a volatile ether.

There is no boundary line then between organic and inorganic substances, neither is there any boundary line between plants and animals, Diatomaceæ being placed by some observers in the animal, and by others in the vegetable kingdom. Reasoning by analogy, I believe that we shall before long find it an equally difficult task to draw a distinction between the lowest forms of living matter and

dead matter. The hypothesis that every living thing comes from an egg has given way to another—every living thing comes from a cell.* Probably we shall, in due time, find under what conditions cells are first formed, and thus the lower forms of life created.

But a few years since the question "What is heat?" would have puzzled the greatest philosopher; now, thanks to Dr. Tyndall's valuable work, hundreds of school-boys could answer it.

The problem of the conditions of cell-life is peculiarly a problem for microscopists. Surely much may be hoped for, from their known perseverance and ingenuity, notwithstanding the apparent insolubility of the problem.

It has been stated that crystals never form curved lines. This assertion is not strictly true.

A point of great importance in this connection is that Mr. Rainey has found that when a solution of a lime-salt in gum-arabic is slowly decomposed, carbonate of lime is deposited in spheroidal concretions. Sometimes two of these will unite and form a dumb-bell; occasionally a number will unite in the form of a mulberry. According to Dr. Carpenter, similar concretionary spheroids are common in the urine of the horse, in the auditory sacs of fishes, in the skin of the shrimp, and other imperfectly calcified shells of crustacea, as well as in certain imperfect layers in the shells of mollusca.

Again, it has been stated that carbonate of lime is not deposited in animal substances in the crystalline form. Dr. Carpenter says that the external layer of an ordinary egg-shell consists of a series of polygonal plates resembling a tesselated pavement.

Professor Williamson says that there can be no doubt that the calcareous deposit in the scales of fishes is formed upon the same plan.

Want of space alone prevents me from adding other examples; but from the instances I have given we may see that the presence of organic matter is often sufficient to prevent the deposition of lime in a crystalline form, and to cause it to assume a circular form, either in or out of a living organism; while in the second case we find that vitality does not prevent the deposit of lime in the crystalline form.

In a very suggestive speech Mr. Slack referred to the triumphs of modern chemistry—the building up of highly organized substances—synthesis. Dr. Beale objected that no parallel could be fairly drawn here, because the method by which the highly organized substances are produced naturally is so exceedingly

* Even this proposition is extremely questionable. It is certainly unfounded if the current definition of the word "cell" be accepted. Absolutely it resolves itself into this: that living things proceed from a substance which may—following Prof. Huxley—be very fairly though *generally* styled Protoplasm.—Ed. M. M. J.

simple. Is this the case?* Do we not rather find that highly organized substances are never produced except as the result of two or three processes? Man cannot assimilate the elements either of the earth or air to form living matter. They must first be assimilated by the plant. The plant nourishes the animal. The animal serves as food for a higher grade of animals, or for man.

According to good authorities, osmose will take place against a pressure of several atmospheres. It should be borne in mind that this passage of liquids against pressure takes place through plaster of Paris, carbonate of lime, and even earthenware, as well as through animal and vegetable membranes.

Referring to this point I find the following important passage in Watt's 'Dictionary of Chemistry':—

"In osmose there is a remarkably direct substitution of one of the great forces of nature for another force—the conversion, namely, of chemical action into mechanical power.†

"Viewed in this light, the osmotic injection of fluids may, perhaps, supply the deficient link which intervenes between chemical decomposition and muscular movement. The ascent of the sap in plants appears to depend upon a similar conversion of chemical, or, at least, molecular action into mechanical force. The juices of plants are constantly permeating the coatings of the superficial vessels in the leaves and other organs; and as these evaporate into the air, a fresh portion of the liquid is absorbed by the membrane, and evaporates; and thus a regular upward current is established, by which the sap is transferred from the roots to the highest parts of the tree.

"In a similar manner, the evaporation constantly taking place from the skin and lungs of animals, causes a continuous flow of the animal juices from the interior towards the surface."

I think we have seen that we do not need to assume the action of a special vital force to carry on these all-important changes of secretion and excretion in plants and animals.

Physiologists who agree with Dr. Beale always point to the fact that oxygen attacks some tissues of the living body and spares others; but a parallel to this can be found in the behaviour of the metal-plates in a voltaic cell, consisting of a plate of zinc and plate of copper in dilute acid. So long as they are not united, no action takes place. The moment, however, that a connection is established between them, the zinc rapidly decomposes the water, with the evolution of hydrogen gas.

The nervous system may possess a controlling power which can suspend the action of the respired oxygen, or permit it to take effect.

* The answer to the question is, that we really know nothing about it.—Ed. M. M. J.

† Vol. v., 721.

We are continually asked why we object to the term vital force? For the same reason that in previous ages other advanced thinkers have objected to various phenomena of nature being explained, by the supposition of the action of "*phlogiston*," and of the great principle so long firmly believed in, that "*nature abhors a vacuum.*"

In fact, our point lies in this simple fact—that men are apt to believe that they have got *ideas*, whereas they have only got *words*.

Space forbids me to enlarge on this tendency, but I must give one illustration.

There are many substances known to chemists, both simple and compound, which will not unite when brought together, unless a third substance be present. Yet after their union no alteration can be detected in this third substance, which has apparently effected the change. This action has been named a catalytic action, and two distinguished foreign chemists have supposed that there must be a special *catalytic force*. Some of our leading English chemists have preferred to call this action simply *contact action*. Doubtless, experiments will at last enable us to understand what action ensues when these contacts occur, and thus furnish us with an explanation instead of a name.

The only condition on which life can be sustained is that of unceasing death. The death of the cells is indispensable to the life of the being. How can we escape the conclusion, that the life of the individual is the sum total of the life contained in the matter of which the cells were composed? When we evolve heat by the combustion of coal, we acknowledge that we simply reproduce the solar heat that had been absorbed by the coal-plants. If we admit the hypothesis of spontaneous generation, we have to admit that the power of forming cells must have existed in the elements of which they are composed, and that only favourable conditions were required to enable the first cell to be produced.

"Dr. Beale objects that living and non-living protoplasm cannot be regarded as the same substance, and therefore ought not to be called by the same name."*

We speak of bone and flesh, hair and skin and nails, whether alive or dead; why should we be called on to give two names to protoplasm?

One of the most curious and interesting, I have heard it called the most inexplicable, of all the phenomena of life, is that of suspended animation, let us say, by drowning, when by the application of electricity, heat, or artificial respiration, the life is apparently restored.

* Dr. Beale has never given any satisfactory reason for this division of the materials of the tissues into living and dead. The argument from the use of carmine is, in our opinion, simply a *Petitio principii.*—Ed. M. M. J.

Yet this phenomena may be imitated with a common pendulum clock which has been stopped, and which can be set going by blowing the pendulum, and will appear self-sustaining afterwards.

Of course this does not occasion any surprise, because we know that the power of gravity serves to keep the clock in motion.

In time, by diligent research, the greater mystery will, doubtless, be revealed to us.

It will be worse than useless, nay, it will, as tending to retard inquiry, be mischievous to set down all the complex actions going on in organized beings as the result of a special vital force, until we are certain that it is hopeless to expect any further addition to our knowledge. Can we ever be certain of this? What do we know of the power of electrical force, or the extent of its action?

We know that it will unite the inert elements of our atmosphere, and cause them to form the corrosive liquid nitric acid. We know, also, that it will rend asunder sodium and oxygen. It will cause an iron rod to expand, a muscle to contract. It is most improbable that we know the full extent of its action in the animal economy.

A distinguished French philosopher, the Abbé Hauy, writes:—"Those specious causes and imaginary powers to which, in the Middle Ages, all natural phenomena, even those of an astronomical kind, were referred, but which, through the genius of Newton and Laplace, have been banished from the celestial spaces, have taken their last refuge in the recesses of organized beings, and from these retreats positive philosophy is preparing to expel them."

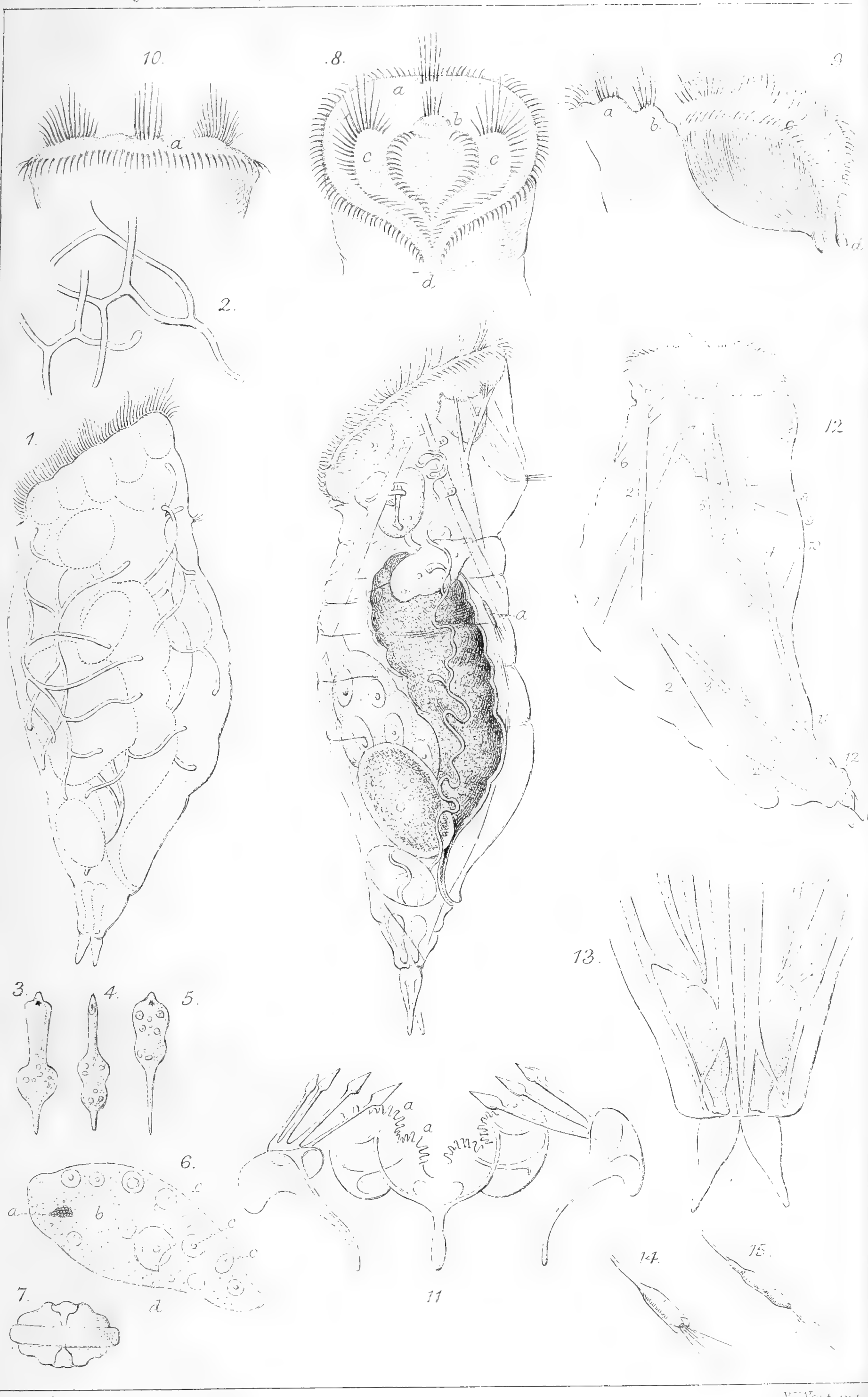
Why are researches in this direction opposed, or regarded with prejudice? As a result of them we may hope to arrive at the truth; and surely, as an eloquent French preacher has said, the nearer we are to truth, the nearer we are to God.

V.—*Notes on Hydatina Senta.* By C. T. Hudson, LL.D.

Plate XIX.

There is so little known of the life-history of the Rotifers, and so many points of their structure remain unexplained, that it seems at first quite superfluous to notice any of their diseases; and yet I am tempted to record the following facts, as they may prove interesting to those who are engaged in the same study as myself.

In the beginning of February I found Hydatina Senta in tolerable abundance at Bedminster, in a large rain-puddle into which manure-water trickled. On returning a few days afterwards for some more specimens, I fished all round the puddle, and at different depths, in vain; but in a hoof-print close to the puddle, and



Auctor del. Tuffen West sc. W. West imp.

Structure of Hydatina senta.

filled from it, there were plenty of Hydatina, and this small reservoir continued to supply me with fresh specimens for nearly a fortnight, while they were never to be found in the puddle. At the end of the fortnight all the rotifers disappeared, although, so far as I could see, there was no change of any of the circumstances under which they had previously thriven. The only thing which had altered was the temperature, which had suddenly fallen, and perhaps this was a fatal change to rotifers in so small a quantity of water as that contained in a hoof-print; but why they should have originally deserted the puddle for such a preposterous residence I cannot imagine.

Almost all the specimens I obtained from Bedminster contained internal parasites; while a few had what appeared to be the mycelium of a fungus growing in the space between the cuticle and the internal organs. The white network of the mycelium stretched into every portion of this space, and surrounded (though loosely) the stomach, mastax, ovary, &c. &c.; frequently crossing the larger muscles and bending them out of their proper directions; but the creature did not seem to be distressed in any way by this parasitic growth, and its motions were quite as active as those of a healthy Hydatina. Fig. 1 represents Hydatina held down by a compressorium, and shows the mycelium which I have drawn as accurately as the intricate nature of the meshes would permit; and at Fig. 2 is shown a small portion of the mycelium more highly magnified.

I isolated one or two of the rotifers thus affected, in the hope of seeing a further development of the fungus; but I was not successful, for they all soon died.

The internal parasites of Hydatina I have often seen. They were figured first by Leydig; and a translation of his paper, in which there is a notice of them, was given in the 'Annals of Natural History' for 1857. They are of a narrow oval form, and average $\frac{1}{300}$th of an inch in length; and when in Hydatina's stomach are in incessant and vigorous motion, jerking the contents of their bodies forwards and backwards, so as to make a cylindrical mass travel rapidly to and fro in the most curious manner.

Figs. 3, 4, and 5 are different views of the same animal when in unrestrained motion. While passing through these various shapes, it pushes its way quickly up and down Hydatina's stomach, usually taking up its position close to the upper extremity, and a little to the side of the opening into the œsophagus. Even when the anterior portion of the parasite is right against the walls of the stomach, the cylindrical wave never ceases to travel up and down its body, and occasionally the motion is complicated by a spiral movement being added to the other.

It not unfrequently happens that when the parasites in their travels reach the lower stomach they are suddenly expelled, and for

a short time they will swim straight on as vigorously as ever; but they soon begin to slacken their pace, the characteristic cylinder can scarcely traverse the body, and after a few spiral contortions they lie motionless in the shapeless attitudes which Leydig has drawn in his four upper figures.

On one occasion two of the parasites so expelled started together to cross the field of view, which they did in excellent style, never swerving from a straight line, and passing out of the field, as they entered it, neck and neck. I timed the race, and found that they swam through one-tenth of an inch, or about thirty times their own length, in a minute.

Fig. 6 represents the animal flattened by the compressorium. There is a red spot (*a*) near the anterior portion of the body, and clear transparent spaces (*b*, *b*) which frequently change their position and form, though usually circular. The bodies (*c*, *c*, *c*) are of all sizes, from $\frac{1}{2000}$th of an inch downwards. They are hollow and brittle, and can be broken as at (*d*) by flattening the animal. Fig. 7 shows one more highly magnified; it is a roughly spheroidal globe with a half-projecting ring forming what may be termed its equator, and there are at the poles two funnel-shaped cavities whose narrow extremities are turned towards the centre and each other. As these bodies are thrown backwards and forwards by the animal, they turn over and move freely among each other.

It is a difficult matter to make out satisfactorily the arrangement of the cilia on Hydatina's head, owing to its incessant motion. I have repeatedly watched this rotifer while alive, by dark-ground illumination, as well as by transmitted light, and (availing myself of Leydig's method of killing it) have succeeded in obtaining frequent front, back, and side views of the extended cilia after the animal was dead; and I do not think that either Cohn's or Leydig's figure fairly represents the trochal wreaths. That there are two continuous wreaths, one on the outer and the other on the inner edge of the disc, is obvious enough; and those of the outer row are curved outwards, while those of the inner are curved inwards towards the buccal funnel; but it is the middle row of much larger and straighter cilia which is perplexing. Cohn makes it a succession of detached groups of straight cilia arranged like fans on round protuberances between the inner and outer row. Leydig has, on the whole, a much more accurate figure of the trochal disc, but represents the middle row as "forming a continuous series." Now it does not appear to me that the middle row is either continuous or all broken up into tufts. It is with considerable diffidence that I question Cohn's or Leydig's statements; but as these excellent observers do not agree, there seems to be room for a third opinion.

There are, I think, three main groups of radiating cilia—one (Fig. 8, *a*) on a papilla placed towards the dorsal surface and in the

median line with a smaller similar group on a papilla (*b*) just below it. The two other groups (*c, c*) lie right and left of the large cavity that leads to the buccal funnel, and each is the extremity of a curved row of large cilia lying between the inner and outer small ones, and ending with them at a point (*d*) on the ventral surface opposite to the buccal funnel. Leydig places the aperture of the buccal funnel almost in the centre of the large cavity surrounded by the inner row; but, as shown in Fig. 9 (which is an imaginary section of the head), the whole cavity slopes down towards the ventral surface, and the entrance to the buccal funnel (*d*) is close to it. The other letters in the figure refer to the same parts as in Fig. 8. Fig. 10 is a dorsal view of the top of the trochal disc.

In attempting to make out the structure of the teeth either by crushing the animal or dissolving it in caustic potash, it frequently happens that the parts are so thrown upon each other that a distinct view is impossible; but a few days ago I obtained a specimen capitally placed, and was able to see that the edges of the incus are themselves armed with fine small teeth (Fig. 11, *a, a*), which have not, I believe, been previously noticed, and which no doubt comminute the food that has been partially torn by the larger teeth.

In Fig. 12 are shown the muscles of a specimen that has been killed in bichromate of potash, and compressed so as to make the muscles show their points of attachment. The muscles 1 and 5 retract the head, and so do the anterior portions of 2 and 4, which latter, in conjunction with 3, also act to draw in the foot; 6 is a small muscular thread from the spot where the dorsal setæ are situated to the head; and 7–12 are similar small threads that retain in their places the gastric glands, mastax, stomach, ovary, and contractile vesicle. Of course the figure only represents the muscles on one side of the rotifer: they all occur in pairs, and Fig. 13 shows how curiously they terminate in the foot.

A rocket-shaped body carrying setæ (Fig. 14) exists on either side of Hydatina (Fig. 16, *a*), just as in Triarthra; but it varies a little in shape from similar ones (Fig. 15) that are found at the extremity of Synchœta Tremula.

VI.—*Some Remarks on the Structure of Diatoms and Podura Scales.* By F. H. Wenham.

At the last meeting of the Royal Microscopical Society (June 9) this much-vexed question was again revived, in the discussion following the paper read by the President.

In consequence of the higher powers and more perfect definition

of our object-glasses, made within the last fifteen years, the structure of many of the *Diatoms*, such as *P. angulatum*, *Formosum*, *Balticum*, &c., seems to have been decided, and their nature, as nodules of silex, generally admitted as facts, from the palpable method of examining broken edges of the scale and detached fragments.

Though the *Podura* may be well defined with objectives, which fail to afford even indications of markings on these diatomaceous tests, yet the structure of this scale is far from being satisfactorily determined. To bring out to the best advantage the opaque-looking spines, or "note of exclamation" markings (which is their undoubted form), it is generally admitted that the direct light from an achromatic condenser is the best mode of illumination, as it is also most reliable and free from error, and is the one adopted by the constructor of object-glasses for the final examination of his workmanship, the test marks being this recognized form. Obliquity of illumination would blend and confuse these markings, and produce an appearance much similar to that of spherical aberration in the object-glass itself, and might be mistaken for such.

Let a strongly-marked and suitable *Podura* be now examined with the highest powers, say $\frac{1}{25}$ or $\frac{1}{50}$, using the deepest eye-piece, and even lengthening the body by the draw-tube (and many of our recent object-glasses will bear this admirably), the illumination being that of the achromatic condenser with adjustable apertures. Under these circumstances the scale will be so enormously magnified, that only a small portion of it will occupy the whole field of view, supposing the adjustment for spherical aberration or thickness of glass-cover also to be exactly corrected. Under this excessive amplitude, each individual marking still retains its characteristic form; but though it is a body evidently having some bulk, not the most careful focussing can determine that it stands above the surface of the scale. On the contrary, there is a slight and peculiar shading-off of an apparent intervening membrane next the markings, giving rise to the idea of a kind of rising between them, so that I have known several that have seen the *Podura* under these conditions declare that the markings are actual *depressions*, or dark pigment cells.

Let us next work through this subject with the Binocular microscope. Though it must be admitted that the application of this to difficult tests is not very satisfactory, yet in a coarse *Podura* the markings are sufficiently well defined and still retain their characteristic form, but it utterly fails in throwing the spines up in relief as from an underlying surface, and affords no additional knowledge of the structure; but at the same time, if the entire scale is hollow or distorted, this is immediately detected by the aid of double vision. Further, let the test be examined by some approximate mode of opaque illumination: by this we are limited to much lower

powers by the difficulty of obtaining light, but under the parabolic condenser, with a $\frac{1}{8}$th object-glass and a black field, this is a most brilliant and beautiful object. The so-termed spines still retain their peculiar form and decided materiality; and being as they are, either somewhat opaque or coloured, they retain the light, and now appear luminous instead of dark, as before. In all other respects of interval, form, and position, they are the same as under transmitted light, and we are equally unable to prove that they exist in the form of projections.

We will now consider the effects of fracture or dissection. Mount the scales from a recently-killed *Podura* on thin glass in the usual way. Take a fine needle, and roll and draw it amongst them, so as to mutilate them as much as possible, and place the thin glass on a slide for the examination. The first thing that strikes the observer, is the remarkable flaccidity of the scales. Comparing great things with small, they appear as limber as pieces of wetted paper, and roll up and crumple in a similar manner; and at the spot where the specimens have been most bruised and broken, there is evidently moisture deposited on the glass, showing that the membranes contain fluid when the scale is attached to the living insect. The markings on the surface of such scales as are bruised, are not thrust sideways to any notable degree, they remain much in their original place, and appear merely to be flattened or mashed out to some extent, indicating a very firm attachment. Other scales that are doubled up, or folded over, show the markings *exactly similar on both sides*, and there is nothing peculiar at the line of flexure. If the markings were real spines, they would here stand out like the short bristles of a piece of hide when folded together. But the markings ply round the sharp bend so closely, that the keenest eye cannot detect any appreciable rib or projection at the edge of the fold.

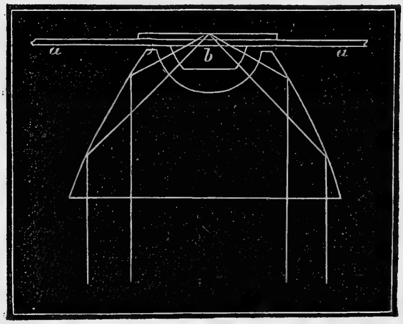
By transferring the investigation to a scale that has been ripped open, or torn across, nothing more can be learnt. The tear continues without interruption clean through the markings, one-half of which will be left on one piece, and the other half on the detached one, and no snags or projections can be seen on the clear edges of the suture.

Not much therefore can be decided, as to the structure of this delicate object, by dissection, as in the case of the *Diatoms*, the brittle nature of whose built-up siliceous skeletons enables them to be broken up into the individual atoms of which they are composed. The only proof afforded by the experiment has been, that the markings of the *Podura* are very strongly attached to the scales, and so incorporated with the membranes that separation cannot be effected. We must therefore again resort to illumination in hopes of solving the mystery.

On March 26th, 1856, I read a paper before the Microscopical Society, "On a Method of Illuminating Opaque Objects under the

Highest Powers of the Microscope," on the principle of "causing rays of light to pass through the under-side of the glass slip upon which the object is mounted, at the proper angle for causing *total internal reflexion from the upper surface of the cover*, which is thus made to act the part of a speculum for throwing the light down upon the underlying objects immersed in the balsam or fluid." The effect of this is that the objects are shown beneath an intense sheet of light, not any of which can enter the object-glass except that from the object itself; consequently the field is perfectly dark. Though this is very easily managed, and in the form here repeated costs but a few pence, yet it has attracted but little notice, and, as far as I know, has been used by no one else but myself. Various modes of effecting this are described in my published paper, but I transcribe the one employed in the present question. Besides the apparatus possessed by most microscopists, it only requires the little truncated lens, *b* (shown full size), which is stuck on the slide by a film of any highly refractive oil, such as that of cassia, or cloves:—

"Fig. 3 is another method; *a a* is a glass slide—under this is cemented with Canada balsam a lens, *b*, nearly hemispherical, with a segment removed so as to leave the thickness equal to about one-third the diameter of the sphere. The flat facet of the lens is blackened. The radius of curvature should be about two-tenths of an inch: the use of the blackened facet is to exclude all rays below the incident angle of total reflexion.



This lens is intended to be used in conjunction with the parabolic condenser, in the manner represented by the figure. The rays from the parabola pass through the surface of the lens in a radial direction without refraction, and proceed till they reach the upper surface of the thin glass cover, where they are totally reflected and converge upon the object; the cover in this instance acts precisely the part of a Leiberkuhn, with the advantage of more perfect reflexion."

As *Podura* scales are generally mounted on the thin glass cover, it must not be expected that *these* will be illuminated as dry objects by such means, for the total reflexion takes place entirely from the top surface of the slide, and not a vestige of the upper objects will be seen. But in the intense black field a few solitary scales will be found illuminated with singular beauty and brilliancy. These have become detached from the cover and lie upon the under slide, and

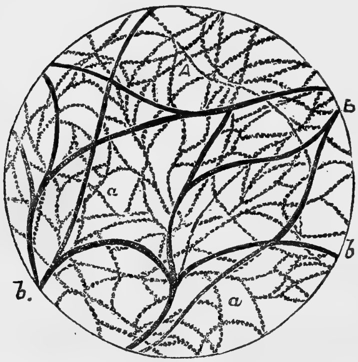
by their close adhesion *prevent the total reflexion of light at the spot beneath,* consequently it is like a hole made in a dark lantern, and a flood of light escapes through the scale. Herein, as with the parabolic condenser, the *markings* are the most intensely illuminated, and appear the brightest; and under a good $\frac{1}{12}$ or $\frac{1}{25}$, contrasted with the surrounding darkness, the aspect of the *Podura* is at the first glance so novel, and different to what we have been accustomed to, that the black interspaces may be mistaken for the markings, *pointed in the reverse direction;* but on looking again, there are still the characteristic " note of exclamation " figures, the same as ever. The rays from the lamp must first be rendered parallel by a bull's-eye condenser. On now sliding this on the table sideways, the light will gradually vanish from the object, and give a dissolving view ; and at last there is only the faint outline of the scale, with its barely perceptible blue surface dotted over irregularly with minute *bright blue circular spots.* This appearance is so different from anything before seen in the *Podura,* that were I to exhibit it as such, not one of its numerous friends would recognize it. But on bringing the light gradually forward again, we have at once most palpable proof that there is no deception. These spots of light emanate from the butt-ends of the markings; for these, having both a higher refractive power, and being also, perhaps from their prominence, in more intimate contact with the glass, are the last portions to admit the light, at the time when the angle becomes so great that the margin is approached, when total reflexion again begins to prevail in the glass against the less refractive power of the scale, which causes its transmission.

As the light is again drawn forward, it plays over the individual markings, and gradually discloses them, from the first bright point to the taper ends. As in this mode of illumination we see the scale as nearly as possible as an opaque object, without the false appearances arising from refraction, I think that it affords some proof that the markings of the *Podura* consist, in reality, of the taper bodies generally known, and which have considerable refractive power and some amount of opacity, and that there are only one series of them. But instead of being planted on *one side* of the scale they are enclosed between *two* membranes. If they were set on one side of a single membrane *some* difference would be observable above and below, and it is well known that there is none. And further, the unprotected markings could be displaced or detached, if they lay on the outer surface only ; and, finally, the mode of illumination herein noticed would merely allow particles of the light to find their way only through the resting-points of the markings, instead of over the whole area of the scale. This affords strong proof that there is a flat membrane in close contact and adhering to the glass surface, destroying the total reflexion in the entire space occupied by the scale.

VII.—*Structure of the Adult Human Vitreous Humour.**
By David Smith, M.D., M.R.C.S.

The almost perfect transparency of the vitreous body has all along been the chief impediment which anatomists have felt in investigating its structure. When it is examined in the fresh state, nothing but a few processes and granules can be detected in it even with the highest magnifying power, and therefore no hope can be entertained of elucidating its structure without the assistance of reagents. Its minute structure may be demonstrated by removing a small fragment from the centre of the humour (thereby avoiding any part of its containing envelope), and placing it on a glass slide, to which is then added a drop of concentrated alcohol. This has the effect of instantaneously rendering the tissue of the humour opaque. Thus treated and subjected to a low magnifying power, a network of reticular tissue is observed in the field of the microscope, dragged about in all directions from the commotion produced by the combination of the alcohol with the fluid of the humour. As this motion soon whips the delicate network of tissue into irregular ropy fibres, which no amount of maceration can again separate, it is necessary, in order to observe the structure more minutely, to cover it immediately after the addition of the alcohol with a thin pellicle of glass. Examined with a power of three hundred diameters, the network of reticular tissue resolves itself into minute tubes or canals, intersected by cells at variable, but still very minute distances apart, thus establishing an anastomosis between cell and cell, as well as between the reticulations (Fig. 1*a*). The tubes are about the size of the elements of connective tissue, and the cells about ten-thousandth of an inch in diameter.

Fig. 1.



A *a a*, Anastomosing cellular tissue of the vitreous humour. B *b b*, Strong, smooth fibres of the cortical portion of the vitreous humour. (Magnified 300 diameters.)

No matter what part of the vitreous humour is examined, the same structure is observed; but in and near the circumference of the humour, and particularly near the zone of Zinn, another set of fibres is superadded. These consist

* By the kind permission of Dr. Wakley, we are enabled to reproduce the following remarks, with illustrations, from the pages of the 'Lancet.'—Ed. M. M. J.

of strong, smooth fibres, not unlike the fibres of common fibrous tissue, which form a coarse, open web, in the large meshes of which the finer network of anastomosing cells is woven (Fig. 1*b*). These fibres are evidently for the purpose of giving strength to the humour in these situations.

The tissue of the vitreous body is entirely composed of an open meshwork, and nothing in the shape of membranes can be seen in it with the microscope. But the microscopic examination of the vitreous humour in detached portions can convey no idea of the design of its structure as a whole; and contrary, therefore, to what might be anticipated from microscopic observation, the strong fibrous tissue, which exists only towards the circumference of the vitreous body, is discovered by the naked eye to be woven into membranes or membranous strata, having a determinate direction within the humour, while the anastomosing cellular tissue, on the other hand, occupies the intermembranous spaces in the manner of loose connective tissue.

To demonstrate these membranes and the intermembranous tissue in their relative situations, it is necessary to have recourse to another method than that already described, for the purpose of rendering the parts opaque as a whole, in order that they may be seen *in situ* with the naked eye. Of the methods which may be employed for this purpose, the one most conclusive and least likely to embarrass the observer is that which allows the tissue to become opaque from age, a small quantity of preservative fluid being used merely to prevent it undergoing the process of putrefaction. To accomplish this, the eyeball should be allowed to stand four or five days in water, when it is to be divested of its tunics, and the vitreous body, with the crystalline lens and capsule, entire, placed in a solution of carbolic acid, of about the strength of one of the latter to three hundred of water. At this stage the vitreous humour is of a straw-yellow or greenish colour, owing to the infiltration into it of the colouring matter of the blood, which somewhat masks the view of the fabric within; but in a few days the sanguineous colouring matter is disseminated into the surrounding menstruum, leaving the structure of the humour quite apparent to the naked eye.

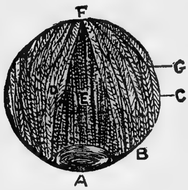
A vitreous body, having been prepared according to the preceding directions, is to be placed in a wine-glass, or other eligible clear glass vessel, covered with water, and examined with the naked eye as the direct rays of the sun are condensed upon it by means of a convex lens. When so examined, the structures within the humour will be found to have the following arrangement:—

(*a*) Passing through the vitreous body from the point where the optic nerve pierces the eyeball to the posterior capsule of the crystalline lens, but inferiorly and internally to the axis of vision,

is the hyaloid canal, which gave passage, in the embryonic eye, to the hyaloid vessels. It is not a constant structure of the adult vitreous humour, and in old age not a trace of it can be found. In some cases, however, it is not only present in the adult, but it remains patent through the whole of its extent, and in such cases, after the vitreous body has been macerated, is often seen to contain opaque granular matter, as if it still conveyed, during adult life, nutriment for the crystalline lens. The hyaloid canal has a diameter about that of a common probe, and, unlike the same structure in its primitive condition in the fœtus, it gives off no branches to the vitreous humour.

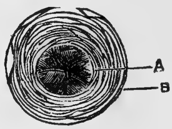
(*b*) Arising at right angles from, and surrounding the inner surface of, the zonula Zinnii, are eight or ten membranous circles, placed the one within the other; each circle, on close examination, being seen to be made up of a series of segments, overlapping and uniting by their edges—the arrangement not being unlike the origin of the leaves of a leaf-bud from a circular disc. Proceeding from this origin, these membranes take a course backwards to the entrance of the hyaloid canal, and in their course split horizontally the entire circumference of the humour into innumerable shallow cells, placed with their flat surfaces to the hyaloid membrane, which build up, layer upon layer, the sides of the vitreous body around the antero-posterior axis of the eyes as a centre (Figs. 2 and 3).

Fig. 2.



Arrangement of the membranous strata within the human vitreous humour (natural size). A, Crystalline lens; B, Zone of Zinn; C, Hyaloid membrane; D, Cortical portion of the humour; E, Medullary portion of the humour; F, Hyaloid canal; G, Radiating fibres.

Fig. 3.



Origin of the membranous strata from the zone of Zinn (natural size). A, Crystalline lens; B, Extreme border of zone.

These membranes are made up of the strong, smooth, fibrous elements already referred to under the microscopic examination of the humour. When they are examined individually with the naked eye by the aid of the direct rays of the sun, they are seen to consist of a flimsy network of fibres, which, for want of a better name, I have called *membranes*, though they scarcely admit of being so classified; and though I have described as *cells* the compartments which the membranes enclose, they are incapable in any degree of limiting the fluid of the humour. The more superficial membranes,

or those which take their origin from the extreme border of the zone of Zinn, have a coarser texture and web than those nearer the axis of the eye; and the former are also more bent in their course backwards, following the curve of the hyaloid membrane, in adaptation to the globular form of the vitreous body. In the vertex, or what may be called the medullary portion of the humour, I have not been able to detect any distinct membranous layers. Faint lines may usually be recognized running backwards in this situation; but they partake of none of the characters of a membrane. Moreover, the central parts are devoid of the strong fibrous tissue which forms the basis of the membranous strata of the cortical portion of the humour.

(*c*) As to the anastomosing cellular tissue, it occupies the medullary portion of the humour behind the crystalline lens and the spaces between the membranes, in the manner of intercellular tissue. It is woven into cellular spaces as receptacles for the vitreous fluid. The filaments of this tissue cross the short diameter of the intermembranous spaces, and therefore they have a radiating direction from the vertex to the sides of the vitreous body (Fig. 2); but, inasmuch as they are finer than the fibres of the membranous strata running from before backwards, they are not so apparent to the naked eye in the prepared specimen. In fact, the intermembranous spaces look to the naked eye as if they merely contain a transparent fluid—a fallacy which is only dispelled by observing them minutely as the direct rays of the sun are thrown upon them, or by touching them with a blunt instrument.

Thus it will be found that while the membranes of the vitreous body are stretched between the zone of Zinn and the fundus of the eye, the anastomosing cellular tissue radiates from the vertex to the sides of the humour—an arrangement which offers the best provision for the prevention of undue distension of the hyaloid membrane from the accumulation of fluid within. It is also not unworthy of note that the membranes, being the strongest fabric of the two, offer the greatest resistance to distension in the direction in which it would be most injurious to vision—namely, in the direction of the axis of the eye. The crystalline lens and retina are by such an arrangement maintained at a fixed distance from each other; and the delicate retina is also protected from undue pressure, between the hyaloid membrane, on the one hand, and the unyielding tunics of the eyeball, on the other.

Such is the structure of the vitreous humour in the adult human subject. It is so fragile, and the proportion which it bears to the vitreous fluid is so small, that it is scarcely to be wondered at that it has escaped notice so long. Its weight makes no appreciable difference in the specific gravity of the fluid of the humour, which is 1053; for if the fluid of the humour be allowed to drain

away, the residue, inclusive of the zonula Zinnii, hyaloid membrane, and posterior capsule of the crystalline lens, does not amount to one grain.

The fluid which occupies the meshes of the vitreous tissue gives to the humour its solidity, as well as its pellucid and highly transparent quality. It has a consistence intermediate between water and the serum of the blood. Of the organic constituents of the blood, the only one which it contains, and that even in very small amount, is albumen. According to Berzelius, the healthy vitreous humour has the following chemical composition:—

Chloride of sodium, with a small quantity of extractive matter soluble in alcohol	1·42
Matter soluble in water	0·02
Albumen	0·16
Water	98·40
	100·00

Millon and Wohler have discovered traces of urea in the fluid of the vitreous humour.*

The fluid of the vitreous humour is chiefly secreted by the ciliary processes; but pathological observation renders it probable that the vessels of the retina take some share in the same process.† Intervening between the substance of the humour and the ciliary processes is the zone of Zinn—a part of the containing envelope of the vitreous humour,—which is a structureless membrane, giving off internally the peculiar structure of the vitreous humour and externally strong fibres, which bind it firmly down to the ciliary processes.‡ The two structures are dovetailed into each other—a highly favourable relationship for the secretion of the vitreous fluid. Through the structureless membrane of the zone of Zinn the vitreous fluid filters in its way to the humour; but, like all other cases in which secretion takes place through membranes without the intervention of cells, the vitreous fluid consists merely of the permeable constituents of the blood. The zone of Zinn seems likely to exercise some influence over the transparency and decoloration of the vitreous fluid during life, for after death the power to resist the coloured constituents of the blood is lost, in consequence of which the vitreous body soon becomes coloured greenish-yellow. A moderate amount of heat also relaxes this membrane so as to facilitate the transudation of fluids through its walls, and consequently inflammatory action of the neighbouring structures will probably

* Carpenter's 'Human Physiology,' 4th edit., p. 54.

† Bowman: 'Lectures on the Parts concerned in the Operations on the Eye,' p. 125.

‡ The structure of the zone of Zinn, as here stated, will be demonstrated in a course of lectures on the Eye, which it is my intention to deliver in Glasgow during the ensuing winter.

have the same effect. It is impossible to say whether, under ordinary circumstances, the secretion of the vitreous fluid is rapid or slow, but a large quantity is known to be thrown out when occasion requires, as when some of it has become evacuated by accident. In such cases, however, the structure of the humour will seldom be reproduced in the fully developed eye.

The fluid escapes so readily from the humour that it has become a problem how nature effects its retention. As will have been observed from the description which has been given of the structure of the humour, it is such as to afford ample facility for a free and rapid circulation of the fluid through its substance; and therefore any force inherent in the tissue itself, such as capillary attraction, can have very little effect in holding the fluid in its meshes. Its retention is readily accounted for by the limited permeability of its enveloping structure—the hyaloid membrane—during life. Even after death, when that membrane has lost much of its resistance to permeation, if the vitreous body be exposed entire, the fluid will take some days to drain away, while a few hours is sufficient if the hyaloid membrane has been lacerated. From the natural firmness of the vitreous body, the retention of the fluid has been accounted for by those who deny that the humour is possessed of any structure, by the fluid in its normal condition having a certain consistence resembling jelly, in which case its exhaustion could only arise from the substance of the humour passing from the semisolid to the fluid condition. This is disproved by the fact that the fluid of the humour can be replaced by any other fluid, such as pure water, spirit, or glycerine, merely by imbibition, and the vitreous body still retain the same physical properties.

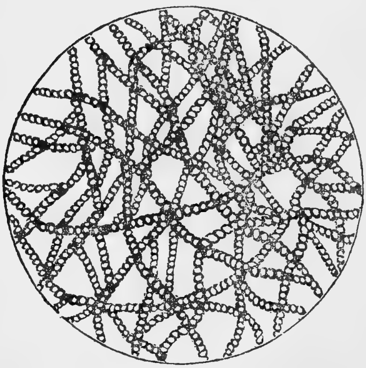
As the vitreous body does not possess any function of a vital nature, and as it has a temperature amongst the lowest of any organ in the body, it is evident that it must undergo little decay, and exercise little demand over the nutritive forces for its renovation. Nevertheless, though it be a non-vascular body, and though the greater part of it be remote from the sources of the circulation, as it is known to undergo various rapid changes in disease, it must possess a proper system of nutrition within itself. In the absence of all other evidence of a nutritive system within the humour, the cellular elements described under the microscopic anatomy of the humour probably contain nutritive materials; and the anastomosis which exists between cell and cell—to adopt the language of Virchow,* on an analogous nutritive system in Wharton's jelly of the umbilical cord,—"renders possible a uniform distribution of the nutritive juices throughout the whole of its substance." The small amount of albumen which exists in the vitreous fluid is incapable in its crude state of being applied to the nutrition of the fabric of

* 'Cellular Pathology,' p. 100.

the humour, and therefore the ciliary processes, as the organs of secretion of the vitreous humour, have probably less reference to the nutrition of its structures than the supply of an abundant and highly transparent fluid for mechanical and physical purposes.

It is a general law in the economy that each atom of the body, by its inherent vitality, must appropriate and transform for its own use whatever nutriment it requires. In accordance with this law, it is the part of the structure of the adult vitreous humour to vitalize the histogenetic material which the vitreous fluid contains, for the renewal of its elements and the maintenance of its transparency. Considered in this light, it is dependent on the ciliary processes for nutriment only in so far as these organs secrete abundantly the vitreous fluid, in which is dissolved a small amount of albumen, but which at the time of its secretion is entirely devoid of organization. On subjecting a fragment of perfectly fresh vitreous humour to the action of dilute nitric acid, the fibres of the anastomosing cellular tissue are observed, under a high magnifying power, to have strung upon them transparent globules, measuring about $\frac{1}{500}$th of an inch in diameter. These globules are quite different, but scarcely distinguishable, from the ordinary vitreous fluid, and may not inaptly be compared to a string of pearls (Fig. 4). They consist of a viscid, highly transparent fluid, and cling to the fibres by their own tenacity, or by vital attraction; they have the form of cells, but they are devoid of any cell-wall, and the ordinary vitreous fluid has no effect in dissolving them; they are so closely set as to touch each other, and they completely mask the view of the fibres which they enclose; and they possess a high degree of refrangibility.

Fig. 4.



Pearly globules attached to the cellular tissue of the vitreous humour. (Magnified 200 diameters.)

Spectra of these globules have been long familiar to natural philosophers and workers with the microscope as frequent sources of interruption to vision in their scientific investigations; but until the present they have eluded the most searching inquiries in the dead subject. The reason of this is that a few hours after death they spontaneously detach themselves from the fibres of the humour, and coalesce into large drops, which in the aggregate have a slightly yellowish colour. A convenient method by which an observer may see these globules in his own eye is by looking through a lens of

short focus at the flame of a candle two or three yards distant;* but by thus viewing them it would never be suspected that they enclose the delicate structure delineated in Fig. 1 (page 376). Besides age in the dead subject, these globules are also rendered more fluid and become detached by the addition of the caustic alkalies, or by the application of a moderate heat, disclosing the structure which they obscured; but they are not dissolved or detached by the dilute mineral acids. Respecting the nature of the fluid of which these globules are composed, it presents no tendency to pass spontaneously into a state of fibrillation, and therefore it has no claims to be ranked with lymph or any of the normal fluids of the body which contain fibrin; and in being quite insoluble in the ordinary vitreous fluid, it is at once distinguished from albumen, at least in the condition in which that substance is secreted by the ciliary processes. In its behaviour with chemical reagents, and in being with difficulty coagulated by heat, it answers to the description of the globulin of the blood. But, whatever name be applied to it, there can be no doubt that it belongs to the albuminous type of compounds; and as the vitreous fluid, when secreted, contains no other histogenetic compound than albumen, it seems a safe deduction that these beautifully transparent globules consist of albumen in the act of undergoing a metamorphosis into a higher state of elaboration. As to the office of these globules in the vitreous humour, by forming an impervious coating upon the fibres of the anastomosing cellular tissue, they protect the latter from maceration in the fluid in which it is constantly bathed, and their plastic property will necessarily add strength to the fibres. But their prime function is, no doubt, the supply of nutriment for the fabric of the humour, or for other parts.

Assuming these globules to be derived in the manner already supposed, their formation is dependent on the assimilating power of the tissue of the humour, which in that case must be endowed with a certain amount of vitality. We have abundant evidence of the existence of this force in the humour: in its development in the embryo; in its organization in the adult; in its undergoing molecular decay, the products of which have been demonstrated in the vitreous fluid by chemical analysis; in its constant maintenance in a state of transparency, though it contains a decomposable structure; and in its undergoing the process of putrefaction after death. It would seem, also, as if the globules adhere to the tissue by the force of vital attraction; for they become detached of their own accord soon after death. But if any doubts exist as to the presence

* For the manner in which the structure of the vitreous humour may be viewed entoptically, see Mackenzie "On the Vision of Objects on and in the Eye," 'Edinburgh Medical and Surgical Journal,' No. 164; also James Jago, M.D., 'On Entoptics,' London, 1864, p. 74.

of vital force in the humour, they are at once dispelled by the evidence of pathology. The vitreous body, or the tissue which it contains, is subject to inflammatory action; it throws out and vitalizes inflammatory products into organized tissue, or matures them into pus; if the tissue of the humour be broken up by the surgeon, or by accident, reaction comes on; and foreign bodies become encysted in lymph in the centre of the humour without obvious assistance from any vascular part of the eyeball. It is presumed, therefore, that these globules, or beads of plastic fluid, owe their formation to the anastomosing cellular tissue of the humour, accumulating around its fibres by its inherent vitality the albumen which the fluid of the humour contains, and elaborating it by prolonged contact into a compound of higher nutritive value; and the obvious relation of these globules to the tissue of the humour, and their attraction for it during life, give them a special reference to the process of nutrition. Such a process has its prototype in the connective tissues of the body (from which the vitreous humour in the embryo is developed), by the serous fluid of the blood, itself unorganized, being converted into organized corpuscles simply by its passage through the meshes of these tissues. With regard to the reason why the plastic fluid, in attaching itself to the fibres of the humour, assumes the corpuscular or globular form rather than a smooth, continuous layer, I do not pretend to offer any precise information at the present time, only that it is a common physical phenomenon in the operation of capillary force.

But besides protecting and nourishing the structure of the humour, the pearly globules of its fibres are probably ultimately destined to serve a still more important end—*viz.* the nutrition of the crystalline lens. Almost two-thirds of the latter body is imbedded in the front of the vitreous humour, both structures lying in close contact. The cellular tissue of the vitreous humour converges towards, and is crowded behind, the crystalline body, to the posterior capsule of which it is adherent, and that so intimately, in the whole of its extent, that the two are never completely separable. The capsule of the lens is a highly transparent membrane, four or five times thicker in front than behind, and in the latter situation forms the only intervening substance between the lens itself and the structure of the vitreous humour. A thin section made in the direction of its thickness, and rendered partially opaque by dilute nitric acid, shows it to be channelled by many tortuous pores, which form indirect communication between its two surfaces. These pores are occupied by a transparent fluid having all the characters of the pearly globules of the vitreous tissue. Near the centre of the posterior capsule a close net-work of extremely minute capillary vessels exists in many of the lower

animals. The crystalline lens is an isolated body in the interior of the eye, and is dependent for its nutrition on one or more of the media which surround it. In many respects its nutrition resembles the same process in the vegetable kingdom. Thus, its structure continues cellular throughout the whole of its existence;* it possesses no nerves, and therefore its nutrition is beyond the influence of the nervous system; the nutrient fluid which its cells contain is globulin,† an albuminous compound which has no tendency to assume spontaneously a higher grade of organization; and lastly, when the structure of the lens is once fully formed, it is subject to little change of material. It has long been held that the lens derives the greater part of its nutriment through the vitreous humour, but the structure of the latter not having been satisfactorily determined, the evidence of this was arrived at by "*exclusion.*"‡ When the choroid or vitreous humour is inflamed, the products arising therefrom are abundantly found in the neighbourhood of the lens, and the latter also participates in the morbid action. If the vitreous humour be disorganized, or a great part of it lost by accident through a wound of the tunics of the eyeball, without injury of the lens, cataract follows; while if the lens be dislocated from its ligamentary attachment, but still adherent to the vitreous body, it generally remains transparent, unless the latter be disorganized. The convergence of the anastomosing cellular tissue of the humour to the posterior surface of the lens indicates an intimate association of the nutrition of the two structures, and this is peculiarly borne out by the structure of the humour in birds. In that division of the animal kingdom the lens undergoes more rapid molecular changes than in any other, and the individuals of this class have a special provision existing within the eye for the supply of the extra demand which necessarily falls upon the nutritive processes. This consists of a process of the choroid, called the *pecten*, which passes through an opening in the retina at the bottom of the eye, and forward in the substance of the vitreous humour to near the posterior surface and external margin of the lens. Filling up the link between the tip of the pecten and the lens is the anastomosing cellular tissue of the humour, which radiates in straight lines from the former to the latter, thus establishing a communication between the vascular choroid and the lens, and which it will scarcely be doubted conveys nutriment to the latter.

These facts point to the vitreous humour as being the principal source through which the lens is nourished, thus confirming the hypothesis which has all along been entertained; but the manner

* Carpenter's 'Human Physiology,' 4th edition, p. 254.

† *Op. cit.*, p. 254.

‡ The structure of the humour, as now revealed, renders this supposition almost a certainty.

in which this takes place has never been explained. As the aqueous humour and the ordinary fluid of the vitreous humour contain only a fractional part of formative material, which, moreover, is entirely destitute of organization, the transudation of these fluids through the capsule, in sufficient quantity to be of any service in the nutrition of the fully-formed lens, would, from the experience we possess of its nature, tend to its disorganization and opacity rather than its nourishment and transparency. Indeed, the capsule of the lens possesses a power which, whether vital or elastic, prevents the transudation of watery fluid through its walls during life —a power which it loses soon after death, and then it allows ingress to the fluid humours of the eye. The same force confers upon it an elective affinity by which it is enabled to take up the small amount of albumen dissolved in the aqueous and vitreous humours; and, therefore, the anterior capsule is probably also concerned to a small extent in the nutrition of the lens. But considering the facts already stated as to the close relationship of the vitreous body and lens, coupled with the additional fact that the anterior capsule is four or five times thicker than the posterior, we must regard the vitreous humour as the reservoir of its nutritive supply. The plastic substance which I have described as adhering to the vitreous tissue in the form of globules is the only compound which the vitreous humour contains capable of undertaking this office, for which it seems well suited in every respect. Its immiscibility in the ordinary fluid of the vitreous humour enables it to be conveyed to the lens in a concentrated state, ready to be received as nutriment by the latter; its plasticity and higher degree of vitality than the ordinary vitreous fluid give it a greater vital and physical attraction for the capsule; while its identity in chemical and physical properties to the fluid that pre-exists in the cells of the crystalline lens makes it as nearly as possible a certainty that it is the pabulum of that body. As the pearly globules have no proper cell-wall, and are not confined to tubes, the onward movement of these to the lens as the latter has a demand for them must be mainly owing to that vital attraction which everywhere exists between pabulum and tissue, and which in the body generally exerts so much influence on the onward movement of the blood in the capillaries. In the present case, however, the elasticity of the fibres on which the globules are strung, as well as the tension of the humour generally, will combine with the vital attraction to give these globules an onward movement corresponding to the direction of the fibres, which is centripetal, or that towards the lens. Thus the crystalline lens of the eye is supplied with transparent nutriment for the repair of its waste by a simple and highly eligible process. It demands its nutriment in a state of concentration and in a high degree of transparency. The colourless elements of the

blood are those only capable of being applied to the nutrition of non-vascular parts; but these elements exist in solution in the serum of the blood in such insignificant quantity, that if the latter were applied directly to the lens it would at once destroy its transparency. But Nature overcomes this obstacle by causing the serum of the blood first to pass through a structureless membrane—the zone of Zinn—to insure its transparency, and afterwards among the meshes of a living structure to separate the formative material from the mass of the fluid in which it is dissolved, and thus by enhancing its vitality renders it capable of ministering to the repair of the lens. This view of the vitreous humour magnifies the importance of its function as a component part of the eye, and makes it as essential to the health of the lens in the adult as it is to its development in the fœtus. Both in the fœtus and adult the vitreous humour is to the lens what the roots are to the plant: it selects the crude material from the blood, elaborates it into nutriment within itself, and, having satisfied its own demands, conducts it onward to the crystalline lens.

As the vitreous humour is one of the chief agents which contributes to the fulness of the globe of the eye, the relation which it bears to the healthy hardness of the latter comes next under consideration. But as the aqueous humour and crystalline lens also contribute a small share in the production of intraocular tension, these last must also be passed in review during the discussion.

Intraocular tension is essentially based upon the distending force of the fluids of the eye, enclosed by membrane and tissue, which give them the character of a spherical solid body. It presupposes two conditions—first, the distending force of the fluids; and, second, the reaction of the membranous sphere upon the fluids. Both of these forces are in constant operation in the healthy eye, and between them, in health, an equilibrium exists, whereby neither gains the ascendency. The last of these will be considered first.

The contents of the eyeball—the aqueous humour, crystalline lens, and vitreous humour—are enclosed within a structureless capsule, which serves to bound and limit them, and unite them into a glassy sphere (Fig. 5). That segment of the sphere which corresponds to the posterior hemisphere goes under the name of *hyaloid membrane* (B); that in the anterior hemisphere, the *posterior elastic lamina of the cornea* (A). These membranes are united in the ciliary body (D), which throws the two segments into a sphere. This union may be demonstrated by making a section of the tunics of the eyeball in their thickness, parallel to the course of the ciliary processes. In such a preparation the posterior elastic lamina (A), after surrounding the anterior chamber in front, as a homogeneous structureless membrane 1-2000 to 1-3000 of an inch

in thickness,* is observed, at the margin of the cornea, to become fibrous and to divide into three parts. One part encircles the rim of the anterior chamber, limiting the fluid which it contains, and passes into the base of the iris and into the ciliary body, in the latter of which situations it becomes blended with the fibrous processes of the zone of Zinn. Of the other parts, the greater gives origin to the ciliary muscle, which is also inserted into the ciliary body; while the lesser portion (E) enters the sclerotica, enclosing the canal of Schlemm. By the latter attachment the sclerotic is indirectly connected with the ciliary circle. Again, the hyaloid membrane (B), after encircling the posterior hemisphere as a thin transparent membrane, is firmly bound down to the ciliary body, where it increases in thickness, and goes under the name of the structureless membrane of Zinn (C), from its discoverer. This union is effected by strong fibres which are given off from the external surface of the latter, pass into the substance of the ciliary body, and meet those, already referred to, coming from the posterior elastic lamina of the cornea. Thus, then, these two membranes become united in the ciliary circle, and form a structureless sphere, the function of which is essentially that of limiting the humours which it encloses. For brevity of description I shall call this sphere the *aqueous capsule of the eye.*

Fig. 5.

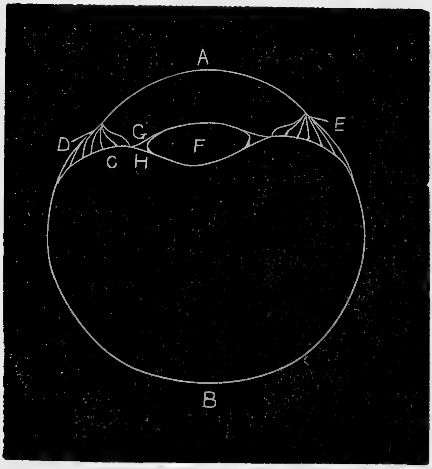


Diagram of the Aqueous Capsule of the Eye.

A, Posterior elastic lamina of the cornea; B, Hyaloid membrane; C, Structureless membrane of Zinn; D, Union of the membranes of the two hemispheres in the ciliary body; E, Fasiculus of fibres which enclose the canal of Schlemm; F, Crystalline lens; G, Ligament of the anterior capsule; H, Ligament of the posterior capsule.

The parts contained within the aqueous capsule are, the aqueous humour, iris crystalline lens, and vitreous humour. It is divided into two segments by the lens (F) and its ligaments (G H); but the division is such as to admit of a certain amount of imbibition between the two hemispheres. This latter fact is of the less importance, as the fluid in the two hemispheres is chemically and physically alike, comes from the one source, distends both hemispheres with an equal degree of force, and its amount in both is regulated by the same principles.

* Bowman: 'Lectures on the Parts concerned in Operations on the Eye,' p. 19.

The vitreous tissue in the posterior segment, and the posterior elastic lamina of the cornea in the anterior segment, confer upon the aqueous capsule the property of elasticity in a high degree, so that it is able to resume its original shape after it has been altered by any of the physiological actions of the eye. The elasticity of the vitreous tissue has been already adverted to (vol. ii. 1868, p. 378). Further evidence that it is possessed of this physical property might be multiplied. I will only mention one other example. Place a fragment of vitreous between two slips of glass, previously rendered opaque by a weak solution of nitrate of silver, to enable its action to be more readily observed. On pressing the glasses in contact the vitreous tissue is observed to expand, and on removing the pressure it instantly regains its former size. The hyaloid membrane is not extensible, though it bears a greater strain than might be at first supposed. The elasticity of the limiting membrane of the anterior hemisphere is a well-established fact.* The elastic structures of the aqueous capsule of the eye contract upon the contained fluid, and give it the character of a solid sphere. In the healthy state of parts it is always full, offering in front a smooth surface for the perfect refraction of the rays of light, and behind for the close adaptation of the retina which is spread out upon it.

But not only is the aqueous capsule, in health, always full, but the fluid which it encloses subjects it to a distending force, against which it reacts in an equal degree. The distending force to which the anterior hemisphere is subjected is often illustrated in practice in cases of ulceration of the cornea. The posterior elastic lamina, in these cases, in losing the support of the lamellated tissue in front, may often be observed to protrude through the bottom of the ulcer in the form of a vesicle. This is caused by the distending force of the fluid within. The distending force of the vitreous body is illustrated by the pressure effects on the central vein of the retina. In the normal state of parts the central artery and vein of the retina, as they pass over the optic disc, are raised above its surface, and are in direct contact with the hyaloid membrane, even projecting somewhat into the substance of the vitreous. In such circumstances the artery does not show any signs of pulsation, but the vein does in many cases; and in all the latter is flattened by the pressure of the vitreous, and pulsation is easily provoked in it. Now, the pulsation of blood-vessels, in any case arises from the resistance which the walls of the vessels or outlying structures give to the distending force of the blood. While, in the eye, therefore, the distending force of the vitreous humour is insufficient to compress the arteria centralis retinæ to that degree which will give rise to pulsation, it is sufficient to flatten the vena centralis retinæ, and to give rise to pulsation, or an intermittent current of blood over the optic disc.

* Bowman: *Op. cit.*, p. 19.

As the vein, in this case, is as much subjected to the pressure of the vitreous as if it were in the centre of the humour, an index of the distending force of that body is thus obtained, which may be roughly estimated as equal, or slightly superior, to the lateral pressure of the blood in the smallest veins.

The distending force, however, to which the aqueous capsule is subjected by the fluid which it encloses is confined within the capsule itself; outside the capsule the distending force ceases to exist. This may be illustrated by the following experiment:—In a dying person, or in a body immediately after death, when the heart is either failing in power or has ceased to beat, the only obvious physical difference in the eye in such a case and that of a person in the vigour of life is, that the choroid has partially emptied itself of blood, and the sclerotica has become soft from the want of support within. In such circumstances, if pressure be made on the eyeball with the two forefingers, the vitreous is felt as a hard globular body within the eye, apparently of its normal position and size. Now, if the vitreous communicated any distending force beyond the hyaloid membrane to the outer tunics of the globe, or if the latter reacted by an elastic force upon the vitreous body, the tension of the eyeball would not diminish in the ratio of the weakness of the heart's impulse, but the place of the receding current of blood would be taken in the one case, by the distending vitreous, in the other by the contracting tunics. That the distending force of the fluids of the eye is borne entirely by the aqueous capsule and structures within it, is also deducible from the difference between the form of the eyeball in health and that which it assumes in some diseases. In the normal eye the aqueous capsule forms a sphere (of which the cornea constitutes a segment), the radius of which is somewhat less than that of the sclerotica, and which cuts the latter at its junction with the cornea. The cornea therefore is more convex than the sclerotica, and at the line of junction a slight depression exists, on account of the angle which the two structures form with each other. The sclerotica forms no part of the sphere, and therefore can sustain no part of the distending force of the fluids of the eye; for if it did, the cornea and sclerotica would be segments of a sphere having the same radius. But when the aqueous capsule becomes enlarged by a superabundance of fluid, such as occurs in glaucoma, the lesser sphere (the aqueous capsule) becomes enlarged, so that the distending force formerly borne by it comes to bear upon the sclerotica; in a word, the lesser sphere merges into that of the sclerotica, and, as a consequence, the cornea takes on the curve of the latter tunic, the depression which normally exists at the junction of the two structures becoming obliterated.—*Lancet, May 8th, et ante.*

VIII.—*On the Use of the Chloride of Gold in Microscopy.*

By Thomas Dwight, jun., M.D.

Perhaps no re-agent has of late years played so important a part in microscopy as chloride of gold. By means of it Conheim first demonstrated the terminations of the nerves in the cornea; and since it has been very generally used, particularly in investigations of the nerves. Its application is very difficult, and it is only after a long series of experiments and failures that proficiency is obtained.

Having had considerable experience with this re-agent in the laboratory of Professor Stricker, in Vienna, and having obtained some very satisfactory results, I hope that a few words on its application may not be out of place. The chloride should be dissolved in distilled water, and the solution should never be stronger than the half of one per cent. The object to be examined should be as fresh as possible, and should remain in the fluid from three minutes to perhaps an hour, according to its affinity for the re-agent, during which time it assumes a pale straw colour. If the piece be small enough to be readily acted upon, ten or fifteen minutes is almost always sufficient. It is then laid in distilled water, to which just enough acetic acid has been added to give it the faintest possible re-action. In two or three days it will have become purple, verging sometimes on blue, sometimes on red; the latter is the least favourable. The preparation is now enclosed in glycerine, and improves for several days as the colour becomes deeper and as the finest fibres are the last to be affected. If the experiment has succeeded—for it sometimes unaccountably fails—the picture presented is one of the most beautiful and instructive that can be imagined. The nerves, muscular fibres, and fibrous tissue appear black on the purple background. Epithelial cells are also coloured, but not so well as by nitrate of silver.

Although the colour makes fibres visible which are so fine that they can be seen by no other method, it does not determine their character. To prove beyond all doubt that a minute fibre is a nerve, we must be able to follow it to a larger branch. On a very successful preparation of the cornea of a frog, I observed nerve-fibres of such minuteness that with a magnifying power of nearly two thousand diameters it was impossible to follow them to their terminations. I particularly endeavoured to verify the connection, asserted by Kühne but not generally accepted, between the nerves and the corneal corpuscles. With every advantage, such a connection is very difficult to prove. I often thought I had found one; but, when examined by a higher power, and placed in different

lights, it proved to be only apparent, except in a single instance, and then it was not certain that the fibre in question was a nerve. I mention these facts as proofs of the value of the method; for it is no paradox to say that the better the preparation the more difficult it is to obtain results. As the magnifying power is increased, elements come into view, which, by inferior methods, are never seen; and spaces are discovered between bodies supposed to be in connection. The use of the chloride of gold, however, is not yet thoroughly understood, and offers a large field for original investigation.—*From the 'Boston Medical and Surgical Journal,' May 27th.*

NEW BOOKS, WITH SHORT NOTICES.

Vegetable Teratology. An Account of the Principal Deviations from the Usual Construction of Plants. By Maxwell T. Masters, M.D., F.L.S. Published for the Ray Society by R. Hardwicke. 1869.—Whether teratology can be profitably studied, to the exclusion of normal histological structure, is a question which we think must be answered in the negative. Therefore, though doubtless readers of Dr. Masters' work are supposed to be already familiar with structural botany, we fear that the minute details of vegetable morphology requisite to a comprehension of the facts recorded by Dr. Masters are not familiar to many. For this reason, we fancy that save among the higher class of botanists this new book of the Ray Society's will not find many admirers. The author has spared no pains to chronicle examples of abnormal structure, and the illustrations in his pages are both numerous and good. We think, too, that most persons will agree with the author's conclusion, that *all* monstrosities are not things *sui generis*, but are merely degrees of multiplication of normal arrangements of parts. But we certainly think it is to be regretted that the facts of normal development of plants were not worked into the text of Dr. Masters' treatise. Of what value are teratological facts if not to clear up our difficulties as to vegetable morphology? Yet from the omission of general plant anatomy and histology, the record of Dr. Masters, valuable as it is, loses much of its usefulness. It seems to us, too, that the author has employed the microscope to a smaller extent than the subject demands. We may, of course, be wrong in this; but we are struck by the fact that many of the continental workers who have lately sought to determine the relation of the axial to the foliar organs have relied on the distribution of the vascular tissues, and have rested on this with advantage. Dr. Masters, however, gives us very little information on these points; and yet we should think that in many cases, where doubt must otherwise exist as to the source of an unusual structure, the microscope would be a sort of crucial test. However, it must in justice be stated that the author disposes of this difficulty by a proposition to which he nearly absolutely assents, *viz.* that there is no distinction at all between axial and foliar elements. We believe it was Locke that quashed the argument between two metaphysicians, who disputed as to the attributes of the soul, by explaining that it was first requisite to prove the existence of such an entity. Dr. Masters places disputants of the Schleiden school in a similar predicament. This, however, is also a question in some measure for the microscopist, and we do not think that Dr. Masters has offered us any satisfactory testimony in regard to it.

We are disposed to think that the author has not quite made up his own mind on this question of the existence of distinct elements, axial and foliar, or else we are at a loss to understand the

tone of the statements in pages 481 to 484. Thus in dealing with the question as to the nature of an "inferior" ovary, Dr. Masters infers that it is foliar, and as evidence of this he cites, among other circumstances, the proposition of "the morphological identity of axis and leaf-organ;" but a little further on, discussing the origin of the ovule and its coverings, he declares, in a very positive manner, that the nucleus is axial and the coverings are foliar. Now, why should the principle apply in the one case more than in the other? Perhaps Dr. Masters will explain.

The great bulk of the text is, of course, of non-microscopical interest, but the treatise is necessarily one of high importance to the scientific botanist, and Dr. Masters must be complimented on having discharged so well a most difficult and tedious task.

PROGRESS OF MICROSCOPICAL SCIENCE.

Apparatus for Injecting Specimens.—An apparatus which is in some measure automatic, and which, at all events, does away with the necessity of a syringe, but which is hardly novel in conception, is described by Herr D. Toldt in the last number of Max Schultze's *Archiv für Mikroskopische Anatomie* (5 Band 2 Heft). The author gives an account of three methods increasing in complexity. The first consists simply of two flasks, and a tube for a mercurial column. The first flask contains the injection fluid, and its cork is perforated by two tubes—one carrying the fluid to the specimen, and the other connecting it with a second flask. This latter is connected with a long tube, funnel-shaped at the extremity, and into which mercury is poured. By this contrivance, the mercury pressing on the air in the first flask presses also on the air in the second, and thus the fluid is steadily compressed and forced into the vessels of the specimen. The mercury flask is provided below with a stop-cock, through which, when the mercury has descended from the perpendicular tube, it may be drawn off for subsequent use. The other two forms of apparatus are a little more complex, and need diagrams for their explanation, but the principle is much the same, water pressure being used instead of mercurial, and manometers being used to gauge the force with which the fluid is pressed on. Any one who has ever worked in a chemist's laboratory can readily understand how the pressure of an ordinary water-tap may be utilized for the purpose of injection. Herr Toldt's idea is based on the method so often adopted by chemists.

The Reproductive System of Saprolegnia monoica.—Herr J. Reinke has given a very minute account of this part of the developmental history of *Saprolegnia*. He describes very minutely the different steps in the formation of the oogonium, and details the production of the antheridia, and illustrates his observations by a plate. See Max Schultze's *Archiv*, ibid.

Terminations of the Nerves in the Pancreatic and Salivary Glands.—Herr Pflüger continues his researches on these points, but he does not add many facts to what he published a few years since. Pflüger's

idea is that the nerves end in the secreting cells, and his drawings tend less or more to confirm his assertion. The illustrations to the present two papers (Max Schultze's *Archiv*, ibid.) do not bear him out as fully as those annexed to his earlier paper. Indeed, we are puzzled to believe that the drawings are not generalized, *i. e.* that they do not represent the observations of several specimens rather than one. We have worked a good deal at both salivary and pancreatic lobules, and with powers higher than Pflüger's (600 diameters), but we certainly never saw anything like the definition of structure he depicts, nor were we able, as he appears to be, to distinguish the fine connective tissue fibres from the fine nerve fibres. It must be said for Pflüger that he used osmic acid, which is stated to bring out nerve structure in a remarkable manner.

The Histology of the Muscular Tissue of the Invertebrata.—Besides the paper we have already mentioned as contained in the last number of Schultze's *Archiv*, is a most valuable and elaborate contribution by V. G. Schwalbe, of Amsterdam, on the characters of the muscular fibres in most invertebrate animals. He goes through several types, beginning with the Actinia, and ending with Echinoderms and Gastropods. Two handsome folding plates illustrate the memoir, and represent the muscular fibres as prepared with chromic acid, bichromate of potash, and osmic acid, and seen with a No. 10 Hartnack's immersion lens. The fibres of some of the annelids (like Nereis) are peculiar in possessing a number of lateral processes In others the sarcolemma is indicated, though it may of course be asked in how far it is a post-mortem or artificial structure, or how far it is represented by the connective tissue which unites the muscular fibres together. The markings on some of the fibres can hardly be taken to represent striæ. They rather recall the appearance seen on badly illuminated specimens of certain diatomaceæ.

Foreign Microscopes.—Again referring to the last issue of Schultze's *Archiv*, we find an interesting, though sketchy account, by Dr. Leopold Dippel, of the different microscopes which may be had abroad, and which are sufficiently good for general work, for hospital use, and so forth. The prices and the names of makers are in all cases given.

The Structure of Bryozoa.—The anatomy of *Cyphonautes* and of *Membranipora* is given by Herr A. Schneider, in a memoir of nearly 20 pages. The plates contain several well-drawn figures, illustrating the anatomy of *C. compressus* and *M. pilosa*. The author deals with the mode of classification also.—Schultze's *Archiv*, 5 Band 2 Heft.

Reichert and Du Bois Reymond's Archiv.—The last number (May) of this contains hardly any histological matters, though it has some anatomical papers of considerable interest.

The Central Nervous System of Birds and Mammals.—It would be impossible to abstract the lengthy memoir on this subject, by Dr. Stieda, of Dorpat, in Siebold and Kölliker's *Zeitschrift* [May]. It extends over more than 90 pages, and treats of the microscopic relation of cells and fibres in both the brain and spinal cord. The plates are three in number, and embrace about 60 beautifully drawn figures.

The Development of Alciope.—Dr. Buchholz, of Greifswald, has given a short account of the development of the curious annelid,

which is parasitic on *Cydippi*, and which was studied by MM. Claparède and Panceri. He gives a magnified coloured figure of the larva of the animal, and proposes to call it *Alciope Pancerii.*—Siebold and Kölliker's *Zeitschrift.* May.

Crustacea Parasitic on Ascidians.—The above-named naturalist, Herr Buchholz, has published a magnificent memoir on these animals, in the May number of Siebold and Kölliker's *Zeitschrift.* It minutely describes a multitude of forms, and is accompanied by seven folding plates, giving handsome enlarged coloured illustrations of some very singular crustacean parasites.

Development of the Organs of Generation in Phallusia.—M. Paul Stepanoff has published a short account of the development of the reproductive system in *Phallusia.* A quarto plate illustrates the paper.—*Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg*, t. XIII.

Comparative Embryology.—Professor Metschnikow is publishing a sort of *mélange* of his observations on development. In the *Bulletin* of the St. Petersburg Academy above cited he describes his researches on the following :—Metamorphoses of *Suncularia ;* Development of *Ophiolepis squammata ;* Metamorphoses of *Ophiuridæ ;* Metamorphoses of *Nemertes ;* Development of *Bothrocephalus proboscideus ;* The Larva of *Botryllus ;* On the Development of Ascidians—in describing this, he refers to a structure which he thinks corresponds to the Chorda dorsalis of Vertebrates!—On the Embryology of Scorpions.

Structure of the Wing in Orthoptera.—M. de Saussure concludes his paper on this subject in the *Annales des Sciences Naturelles*, t. X., May. The author here sums up the conclusions he draws from his observations. These, however, are hardly of interest to microscopists, as they deal nearly solely with the methods in which the wing is folded under the elytron.

Anatomy of Perichæta.—Those interested in the structure of the earth-worm group will do well to read a paper "On the Anatomy of Two Species of the genus Perichæta" by M. Leon Vaillant, in the last *Annales des Sciences Naturelles.* The anatomy is tolerably fully stated. The cerebral ganglion resembles that of the earth-worm, but the division into two parts is less distinctly marked. The digestive apparatus is, he says, extremely like that of the earth-worm. Hermaphroditism is the rule.

The Adenoid Tissue of the Nasal Part of the Pharynx is an excellent paper in the *Journal de l'Anatomie* (June), by Professor Luschka, of Tübingen.

The Mucus of the Arch of the Pharynx is also a good, though brief, paper in the same journal, and by the editor, M. Ch. Robin.

The Structure of the Axis-cylinder of Nerve.—According to M. Grandry's late observations, the axis-cylinder is not a uniform, homogeneous filament, but is composed of a number of discs of two kinds, alternating with each other, and arranged end to end.—See Robin's *Journal*, June.

The Proliferation of the Connective Elements of the Perivascular Canals of the Central Nervous System in Children is a paper of two or three pages by M. Lépine in the *Archives de Physiologie* for June.

The Sleep of Plants is hardly a histologic paper, but we call attention to it, as it may interest our readers. It is by M. Ch. Royer, in the Botanical Section of the last *Annales des Sciences Naturelles*, May.

Brunetti's Process for preparing Anatomical Specimens.—Brunetti's process has this advantage over some others (such as those of Gorini and Segato), that it is adapted to specimens intended for microscopical examination. The following is an account of the process. It consists of four stages, namely, washing, divesting of fat, treating with tannin, and desiccation. A stream of pure water is injected through the blood-vessels and secretory ducts of the part to be preserved; the water is afterwards expelled by means of alcohol. To remove the fat, the vessels are in like manner injected with ether, which penetrates the tissues and dissolves all the fatty matters. These operations occupy a couple of hours, and the object thus prepared may then be kept for a long time in ether if desired. A solution of tannin in distilled water is next injected in a similar manner, and the ether washed out by a stream of pure water. The desiccation is accomplished as follows:—The preparation is placed in a double-bottomed vessel containing boiling water—a sort of *bain marie*—in order to displace the fluid previously used by dry, heated air. Air compressed in a reservoir to about two atmospheres is forced into the vessels and ducts through heated tubes containing chloride of calcium; all moisture is thus expelled and the process is completed. The preparation thus treated is light, and retains its volume, its normal consistence, and all its histological elements. The most delicate sections may be practised in any direction, and accurate observations made with the microscope. The relative position of the organs and tissues being preserved, much better opportunities for pathologico-anatomical demonstration are afforded than by the former inadequate method of preservation in alcohol. The blood being expelled, pathological coloration is alone perceptible.

A New Process for Photomicrography.—M. Bourmans has described (*Les Mondes*, May 27th) a method which, though it has some imperfections, may be found useful. It is described and somewhat severely criticized in the 'British Journal of Photography,' from whose pages we take the following description:—"The plan consists in employing an ordinary microscope having a mirror fixed in the tube between the eyepiece and the object-glass of the instrument. This mirror is lightly-silvered glass, and the light reflected from its surface is thrown out of the instrument laterally, and at a right angle to the course of the rays leaving the object-glass. The rays so deflected from their ordinary path pass on and are received on a focussing-glass or on the sensitive plate. But the mirror, while reflecting a large proportion of the rays, transmits, according to M. Bourmans, about 25 per cent. of the total light which it receives, and the rays so transmitted pass on to the eyepiece of the instrument and finally reach the eye of the observer. When an object has to be photographed, it is suitably placed on the stage of the microscope, and viewed in the ordinary way through the eyepiece of the instrument. It can then be accurately focussed by means of the small amount of light passing through the mirror. Having placed the sensitive plate in its carrier, but pro-

tected from light by a shutter, the object is now caught at the right moment, the shutter turned aside by means of a milled head, and the plate exposed for a suitable time. Even during exposure the object on the stage can be watched in the usual way through the eye-piece of the instrument without in any way interfering with the process." Our readers will perceive that the principle is the same as that employed in illuminating opaque objects under high powers.

The Structure of the Pancreas.—In a memoir presented to the *Académie des Sciences* on the 31st of May, M. Giannuzzi stated the results of his observations on the pancreas. They are briefly as follows:—(1.) The excretory canals of the pancreas have very delicate walls, which are lined by a cylindrical epithelium. They have not the same connection with the secreting follicles as the salivary ducts have, but they form around these a network of fine tubes, which have no epithelium, and which enclose in their meshes the pancreatic cells. They may be compared to the biliary networks. (2.) The network of the excreting canals of different vesicles, which form the same glandular lobule, form connections to constitute a common network. (3.) The blood-vessels follow the general course of the ducts. They surround the vesicles, as capillaries which lie in the meshes of the network of ducts. (4.) The pancreatic vesicles have no wall. (5.) The pavement-epithelium of the vesicles is formed of flattened cells with a nucleus and prolongation. They are very like those of the salivary glands, but the nuclei are more readily seen, and the contents are more fatty and granular. (6.) The injections of the pancreatic canals were made with Prussian blue, and that of the blood-vessels with gelatine and carmine. The apparatus employed was the pressure apparatus of Ludwig.

The Histology of the Lips of the Infant.—In a paper lately presented to the Vienna Academy, Herr Klein gave an account of the structure of the lips of the new-born child. The histologic structure of these organs allows of three regions being distinguished in them, which are (1) the epidermal region, (2) the region of transition, and (3) that of the mucous membrane. The buccal cavity of the new-born child exhibits towards its anterior portion conical papillæ elevated a millimètre above the surface of the epithelium of the mucous membrane. The author describes a new system of muscular fibres distinct from the annular fibres of the sphincter of the mouth, and from the fibres penetrating the cutis, described by Herr Langer.

Fossil Bryozoa.—At the meeting of the Kaiserliche Akademie of Vienna on the 17th of June, Professor Reuss read a notice upon "The Bryozoa of the Tertiaries of Kischenew in Bess-Arabia."

The Origin of Bacteria.—A memoir on this subject has been written by Dr. Polotebnow, of St. Petersburg. The chief results arrived at by this observer were communicated to the Vienna Academy at its meeting on the 3rd of June by Professor Wiesner. The author states that *Bacterium*, *Vibrio*, and *Spirillum* are all developmental stages of *Penicillium glaucum*. The formation of Vibrio from *Penicillium* may be observed when the spores are maintained at a high temperature.

NOTES AND MEMORANDA.

The State Microscopical Society of Illinois.—This young but thriving association, whose charter of incorporation we last month published, held a grand *soirée* on the 28th of May last. A large number of interesting objects were exhibited. There was, we learn, an excellent display of microscopes on the part of the Society itself.

What to See, and How to See it.—Mr. Metcalfe Johnson's note on this subject we cannot insert; not because it is devoid of interest, but because—as its author is, of course, well aware—it really puts forward nothing that is not to be found in any text-book on Natural Philosophy.

Illumination of Objects under the Microscope.—For similar reasons to those above given, we have been unable, in our Reports of Societies, to insert Mr. Abraham's (Liverpool) paper. We recommend him to read two articles—one by the President, and the other by Mr. Wenham—in the present number.

The British Association will this year hold its meeting at Exeter, under the presidency of Professor Stokes. A great many histological papers are expected. The Natural History departments will be presided over as follows:—Geology: President, Professor Harkness, F.R.S.; Vice-Presidents, Mr. W. Goodwin-Austen, F.R.S., and Mr. W. Pengelly, F.R.S. Biology: President, Professor Rolleston, F.R.S.; Vice-Presidents, Mr. E. Spence Bate, F.R.S.; Mr. E. B. Tylor.

The Hunterian Professorship at the College of Surgeons.—It is reported that Professor Huxley has resigned the chair, and that he will be succeeded by Mr. W. H. Flower, F.R.S., the present Conservator of the Museum.

The French Academy's Prizes in Histology.—At the meeting of the Academy, on the 14th of June, the awards of the several prizes for the year were announced. The prize of Experimental Physiology was given to M. Gerbe for his researches on the ovum in relation to the cicatricule and the vesicle of Purkinje. The Goddard prize was given to M. Ercolani for his researches on the utucular glands of the Uterus. The Désmazère was given to M. Nylander for his researches on the Lichen-flora of New Grenada.

The American Association for the Advancement of Science will hold its eighteenth meeting at Salem, on Wednesday, August 18th. It is intended to give great prominence to microscopy, and the committee have issued a special prospectus calling on microscopists to aid in sending instruments and specimens. Communications should be addressed to Mr. F. W. Putnam, the Local Secretary, Salem, Massachusetts. The titles of papers should be handed in as early as possible, in order to secure their presentation to the Association. Each title should be written on a separate slip of paper, with the author's name and address, and an estimate of the number of minutes required to read the communication. As soon as practicable after entering the titles, the paper itself, or an abstract, must be handed to the Secretary,

and until all these conditions are complied with, no title can appear in the programmes.

Injecting Specimens for Microscopic Purposes.—Mr. T. Sharp sends us the following queries, to which we shall be glad to have the answer of our correspondents. Meanwhile, we append a brief reply. 1st. How is the carmine fluid prepared? 2nd. When a subject is injected, does it require any other preparation, such as hardening or shrinking with anything; and, if so, with what? 3rd. What is the best method of slicing such substances as injected brain, lung, &c.—Answers. (1) See Dr. Beale's 'How to Work with the Microscope.' (2) We ourselves simply place the tissue in glycerine with a minute proportion of carbolic acid. (3) Most persons prefer the razor. We (Ed.) always use Valentin's knife, and, from long practice, find it most convenient.

Seeds of the Caryophyllaceæ.—Those who are engaged in examination of seeds with the microscope, which is really a good field for work, will find a paper of some interest "On the Seeds of the Clove-Pink Family," in the June number of 'Science Gossip.' It contains about a dozen illustrations representing the seeds as magnified from 20 to 40 diameters.

Theonella or Dactylocalyx.—Two zoologists dispute about a sponge. Which will "throw it up?" In the report of the meeting of the Zoological Society, May 27th, we read the following:—A communication was read from Dr. J. S. Bowerbank containing remarks on the Sponge, lately described by Dr. Gray in the Society's 'Proceedings' under the name of *Theonella swinhoei*, which Dr. Bowerbank believed to be a species of *Dactylocalyx*, and identical with his *D. Prattii.*

"Pond-life" Photographed.—Mr. Slack is the historian of Pond-life; but Mr. H. C. Richter is unquestionably its portrait painter. We have before us a photograph taken from a drawing, and which is a veritable "study from life" of the organic world of the microscope. It is an oval picture (about 7 inches by 5) which portrays the types of the several forms of life seen under the microscope, and it is no less a *chef-d'œuvre* of artistic excellence than of skilled zoological representation; and while it depicts the various organisms with a minuteness of detail which only a patient student can realize, and has placed each element in its natural position, its *tout-ensemble* conveys a notion of grace and truth. The subjoined list of the species included in this picture gives some idea of its high scientific value:—

1. *Stephanoceros Eichornii:* Crown animalcule (Rotifer). 2. The same; retracted into its gelatinous tube. 3. *Melicerta ringens* (Rotifer). 4. The same; another view. 5. The same; partly retracted. 6. The same; *young* with *gelatinous tube.* 7. *Floscularia ornata* (Rotifer). 8. The same; an old specimen. 9. The same; retracted into its tube. 10. *Rotifer vulgaris;* swimming freely. 11. The same; crawling along. 12. *Dinocharis tetractis* (Rotifer). 13. *Petrodina patina* (Rotifer). 14. *Œcistes longicornis* (Davis), new species (Rotifer). 15. *Macrobiotus Hufelandii.* Water bears (Tardigrada). 16. *Canthocamptus minutus* (Entomostracan). 17. *Cothurnia imberbis* (Infusorial).

18. *Stentor Mülleri* (Infusorial). 19. The same; retracted into its tube. 20. The same; detached and swimming freely. 21. *Vorticella nebulifera* (Infusorial). 22. *Volvox globator* (Confervoidæ). 23. *Euastrum didelta* (Desmid). 24. *Cosmarium tetraophthalmum* (Desmid). 25. *Pediastrum granulatum* (Desmid). 26. *Closterium lunula* (Desmid). 27. *Closterium moniliferum* (Desmid). 28. *Micrasterias denticulata* (Desmid). 29. *Tabellaria* ——— ? (Diatom). 30. *Spirogyra* ——— (Confervoidæ). 31. *Licmophora* ——— (Diatom). 32. *Synedra* ——— (Diatom). 33. *Arcella vulgaris* (Infusorial). 33*. Attached zoospore of Conferva. 34. *Stigeoclonium protensum* (Confervoidæ). 35. *Cosmarium* ——— ? (Desmid). 36. *Bulbochœte setigeria.*

We would especially call attention to the *Floscularia*, which, when looked at with a lens (and by the way all the figures bear magnification), is exquisitely life-like. Mr. Richter has selected for his picture the motto "Maxime miranda in minimis," which he certainly has done much to establish. The photographs are sold by Messrs. Ross, of Wigmore Street, and Messrs. Baker, of Holborn.

Microscopical Slides.—The American "Essex Institute" has established a sort of manufactory of microscopical sections of all kinds. Mr. Alpheus Hyatt, the author of a memoir of the Polyzoa, is the secretary, and to him communications, objects, &c., should be addressed. The following is the prospectus published:—"This establishment, founded by the liberal aid of citizens of Salem, Boston, and New York, is now in successful operation. We have secured the services of the well-known preparator, Mr. E. Bicknell, and the completeness of our apparatus affords facilities for the production of a style of slide inferior to none, whether of native or foreign manufacture. We will supply suites of Histological specimens for educational purposes. Preparations of bone, teeth including the jaw, shells, corals, spines and shells of Echini, or other hard tissues; also thin sections of wood. Preparations of injured grain with its microscopial pests, if specimens are sent or special orders given. Suites of specimens suitable for the beginner in microscopy, or for the connoisseur seeking amusement and instruction combined. *Coarser Preparations.*—Shells and corals, fossil or recent, cut and polished. These show the columella of the shells, and the cells of the coral in the most effective way for general study. Slides or preparations will be exchanged for specimens desired. Special attention given to preparations intended for scientific investigation.

A Year-Book of American Entomology during the year 1868 is about to be issued. It will be edited by Dr. A. S. Packard, jun., whose excellent treatise on insects we some time since noticed in these pages. Dr. J. L. Leconte will contribute a chapter on the Cleoptera; Mr. S. H. Scudder, chapters on the Butterflies and Orthoptera; Baron R. Osten Sacken, a chapter on the Diptera; Mr. P. H. Uhler, a chapter on the Hemiptera and Neuroptera; the Editor, chapters on the Hymenoptera and Moths; and Dr. Hagan, an article on the False Scorpions.

What the Microscope has done.—In a paper, written by M. Löwenthal, and published in the *Pharmaceutische Zertschrift für Russland* (April), an account is given of one of the most striking disco-

veries made by the aid of the microscope from the time of Leenwenhoek to the present period.

Selenite Plates for the Microscope.—Some very excellent and remarkably cheap selenite plates were recently shown us by Mr. W. Bestall (4, Warrior Road, Camberwell New Road, S.E.), who prepares also a very simple and inexpensive form of polariscope, which those interested in polariscopy would do well to examine for themselves.

PROCEEDINGS OF SOCIETIES.*

Royal Microscopical Society.†

King's College, *June* 9, 1869.

The President (Rev. J. B. Reade, M.A., F.R.S.), in the chair.

The minutes of the last meeting were read and confirmed.

A list of donations to the Society was then read; and Mr. Jabez Hogg asked the Society to accept a new edition of his work on the Microscope.

Mr. Hogg announced that he had received from the widow of the late Dr. W. B. Herapath, of Bristol, the inventor of the Herapathite, a number of specimens of that crystal, which would be found very useful for polarizing; and that any Fellow of the Society who might wish to possess one, could obtain it of the Assistant-Secretary (Mr. Reeves), at a cost of about two shillings.

The President having intimated that Dr. Eulenstein had a matter of business to bring before the meeting.

Dr. Eulenstein said it was probably well known that the late Dr. Arnott possessed one of the most complete collections of Diatoms in existence. That collection was about to be sold, and he had arranged to purchase it. A full and particular list had been made of the collection, and any gentleman who wished to obtain specimens would be supplied with a catalogue on application, and the slides selected would be delivered during the current summer.

The President said it would be very desirable for the Society to possess such a collection as that to which Dr. Eulenstein had referred; and he presumed that if the Council undertook the responsibility of purchasing sets, the Fellows would be willing to indemnify them for the same.

He also thought it advisable to make some reference to a series of papers on "The Construction of Object-glasses for the Microscope," of which Mr. F. H. Wenham was the author. These papers had appeared in the Journal ostensibly as communications addressed to the editor. They had, however, been published in that form as a

* Secretaries of Societies will greatly oblige us by writing out their reports legibly—especially the technical terms—and by "underlining" words, such as specific names, which must be printed in italics. They will thus ensure accuracy and enhance the value of their proceedings.—Ed. M. M. J.

† Report supplied by the Secretaries.

matter of convenience, and the articles must be considered as communications addressed to the Society. He (the President) hoped to invite discussion upon the subject at a future period.

The President then proceeded to read a paper on "The Diatom Prism and the True Form of Diatom Markings." *

Mr. Wenham said: Some time since he had determined the markings on some diatoms to be spherical, and that this discovery had not been made by any special mode of illumination, but by the examination of fractured specimens. In one of the fragments of *Quadratum* a line of spherules had been detached like a row of beads. At the extreme end a single spherule had separated sufficiently to enable it to be examined in an isolated state. In another case a small piece of the scale had been broken out and laid over close to the opening, thus affording an immediate comparison of both sides of the scale at the same time, and clearly proving the appearance to be exactly similar on either. The diatoms in question are exceedingly brittle; and if some of them are placed on a slide with water, and thin glass-cover pressed hard down, and the whole left till dry, on slightly moving the cover some of them will be broken, a portion of the fragments adhering to each glass surface in various forms of dissection. The President confirmed in a remarkable way the views which he (Mr. Wenham) had entertained. An item of great value in the mode of illumination used by the President was the length of the prism, which threw a line of light from the condenser; and he thought that, by using a shorter prism of only one-fourth of the length, the same effect would not be produced. The relief in which the object was seen was very remarkable. In fact, it had all the appearance of a solid body illuminated from above.

Mr. Browning said it was gratifying to know, that after having bestowed so much labour on the attempt to resolve the markings on diatoms, the President was able to exhibit the real facts by so simple a method.

(The President explained that he had been able to use a power as low as the $\frac{2}{3}$ inch).

Mr. Slack said it was very interesting to find that the deposition of silica in the living diatom takes place under purely physical laws; and the appearances which had been described as occurring on the diatom-valves are exactly what can be produced in making artificial diatoms by Max-Schultze's process. The structure of the diatom-valve shows that the so-called "vital forces" do not trouble themselves to interfere with the deposition of silica, according to chemical and physical laws. He had never seen the markings on diatoms so well and clearly shown as by the President's method, though he had long distrusted any mode of displaying them that did not lead to the same results.

Mr. Joseph Beck said it would be in the recollection of the Fellows that his late brother made a photograph of a common tumbler, the surface of which was covered with hemispherical elevations; and that the photograph was made for the purpose of showing that the hemispheres, under certain conditions, would present the appearance

* This valuable communication is published in the present Number.—Ed.

of hexagonal structure, and that this appearance was due to the direction of the shadow in the one case producing the effect of elevations, in the other of depressions. From this appearance his brother had argued very strongly, in regard to the markings of some diatoms, that they were caused by hemispherical nodules.

He (Mr. J. Beck) had examined some specimens of silex artificially deposited, and amongst the more delicate fragments were pieces exactly resembling *Pleurosigma* in structure; and on examining the coarser fragments, which were similar to the more delicate ones in structure, he found them to consist of hemispherical nodules deposited at regular intervals on siliceous plates, showing clearly that an appearance similar to that seen in the *Pleurosigma* could be produced artificially, and affording a strong argument that the markings were due to hemispherical nodules lying on a siliceous plate. At the same time he did not consider the difficulty solved, for the markings on some of the larger Diatomaceæ, as Isthmia, Triceratium, Pinnularia, &c., could not be accounted for in this way. The difficulties of ascertaining real structure from the appearance presented might be seen by taking a piece of zinc pierced with round holes and allowing the sun-light to pass through it upon a sheet of paper; if held at a certain distance there would be an image of round holes; but if the paper were removed or brought closer to the plate, the appearance of black hexagonal dots or of light hexagonal interspaces would be produced. He did not wish for one moment to undervalue the discovery of the President; but he thought more knowledge of the structure of an object could be obtained by the use of a variety of modes of illumination than by the observer restricting himself to the use of one only.

Dr. Eulenstein thought the structures observed in the larger diatoms quite different from some of those of which the President had spoken. As regards, however, the nature of the markings on the *Pleurosigma angulatum*, he had, after examination with Powell's $\frac{1}{50}$th and Hartnack's immersion lens, observed that the character of the dots was hemispherical, a conclusion which Hartnack had disputed. But he was not disposed to believe that the dots were complete spheres of silex.

Mr. Hogg said he had, in conjunction with Mr. Mayall, paid much attention to the subject in question, and he had come to the conclusion that the markings in question were not merely dots. Hartnack was now quite willing to admit that he had been in error with regard to the diatom markings, and that they were really raised spherical dots.

Mr. Lobb said that for years he had considered the markings of the *Pleurosigma* spherical, and indeed had never looked upon them as anything else; and he was glad to find that his belief could be confirmed by the use of a low power, and at so little expense.

A vote of thanks to the President was then unanimously passed.

Mr. Hogg then read a paper "On the Results of Spectrum Analysis."

Mr. Hogg also informed the Fellows that Dr. Herapath, a short time before his death, had been engaged in making investigations into the spectra of the chlorophyll of vegetable substances, of which he had examined about 250. He (Mr. Hogg) had hoped that these

researches would have led to a paper on the subject addressed to the Society, but Dr. Herapath died before he was able to make any communication to the Society. The only result of the investigations had appeared in a letter which Dr. Herapath had written to a friend, and which he (Mr. Hogg) had been permitted to read to the Fellows.

The letter was accordingly read, and copies of a lithograph exhibiting the characteristic spectral bands of the various substances were distributed among the Fellows, Mr. Hogg expressing his opinion that Dr. Herapath had made a mistake with regard to the colours exhibited in the spectrum of the *Laurestinus* and *Berberry.*

Mr. Ray Lankester said that as he had paid some attention to the spectroscope, he should like to make a few remarks. He was much surprised on hearing Mr. Hogg's paper, seeing that it professed to give the results of spectrum analysis, to find that he omitted all reference to what were really the most important results obtained by its means in biological science, namely, those that related to the action of various gases and other reagents on the blood colouring-matter Hæmoglobin and Cruorin. Dr. Arthur Gamgee, Nawrocki, Preyer, Hoppe-Seyler, and others, had worked most successfully in this direction.

With regard to the late Dr. Herapath's drawings of chlorophyll bands, Mr. Lankester observed that he considered them as of little value, since they were not really accurately measured, whilst a method of preparation had been used which must be fallacious, and which was the same as that which Mr. Hogg recommended. It is useless to extract the chlorophyll from leaves at once by alcohol, they must previously be soaked in water, to extract the vegetable acids which are present in some leaves, and which greatly alter the absorption bands if allowed to act on the chlorophyll. Professor Stokes, of Cambridge, who will in all probability soon publish a detailed account of chlorophyll, by the use first of alcohol and then of bisulphide of carbon, has succeeded in extracting two distinct green bodies from ordinary plant chlorophyll. Mr. Lankester then pointed out the error of Mr. Hogg's assertion that the hæmoglobin found in some house-flies is present in their blood; it is simply in the intestinal canal, having been taken in as food. This erroneous statement was the more to be regretted as it tended to throw confusion on results which Mr. Lankester had himself obtained and published in the 'Journal of Anatomy' two years since, and which he hopes to extend in a report to the British Association this summer. He would particularly commend this line of research to the Fellows of the Society. By the use of the spectroscope, Mr. Lankester had found hæmoglobin in the vascular fluid of annelids of various species—in *Chironomus* larvæ and other larvæ, among insects, and in *Planorbis corneus* among molluscs. His friend, Dr. Edouard Van Beneden, had just given him reason to expect its discovery in certain remarkable parasitic crustaceans discovered by that observer.

Besides this, with the spectroscope chlorophyll may be traced, and should be looked for, in the animal kingdom. He had clearly established its presence and published the fact in *Spongilla fluviatilis*, in *Hydra viridis*, in *Stentor*, and in *Mesostomum viridatum*. This was

an exceedingly interesting branch of inquiry, which could only be successfully prosecuted with the micro-spectroscope, since the quantities of the coloured bodies were too small to admit of chemical analysis. He protested very strongly against the notion ventured on by Mr. Hogg, that thallium had anything to do with the chlorophyll spectrum; indeed he hardly believed that he had heard Mr. Hogg aright. As to the occurrence of copper in the Turacou's feather, its discovery had nothing whatever to do with the spectroscope, as Mr. Hogg had stated, but was made before its spectrum was known;* and the spectrum, now that it is known, has nothing to suggest copper about it. It is a very grave error to fall into to suppose that the absorption spectra of coloured bodies are due to metallic ingredients, they are simply caused by certain combinations of the organic elements composing those bodies. He must also differ entirely from Mr. Hogg as to the interest or value of the experiment made with a discased crystalline lens. It is not possible to distinguish quantitatively by means of the spectroscope at all (even Preyer's recent proposition as to estimation of hæmoglobin being objectionable), and Mr. Lankester believed that no one who knew the abundance of sodium in animal tissues would credit Mr. Hogg's assertion that he could distinguish an increase of sodium in the cataract-lens by means of its flame-spectrum.

A vote of thanks was then passed to Mr. Hogg.

The President announced that Mr. Browning had prepared a short description of a new form of micro-spectroscope which he had made, and by which the most effective results could be obtained, at the very low price of 22*s.* 6*d.*

Owing to the late hour at which the announcement was made, it was ordered that the paper be taken as read.

A paper by Mr. Carruthers, "On the Structure of the Ulodendron," was taken as read, and will appear in the journal.

The President announced that the next meeting would be on the 13th of October, and intimated that during the month of August the library would be closed as usual.

Donations to the Library, June 9, 1869:—

	From
Land and Water. Weekly	*Editor.*
Scientific Opinion. Weekly	*Editor.*
Journal of the Society of Arts	*Society.*
The Student	*Publisher.*
The Canadian Journal	(?)
The Microscope. *7th Edition*	*Author.*

John Armstrong Purefoy Colles, M.D., F.R.C.S.I., was elected a Fellow of the Society.

WALTER W. REEVES,
Assist. Secretary.

* Professor Church, who discovered Turacine, does not seem to agree with Mr. Lankester on this point. In his account of the matter in the 'Student' (vol. i., p. 165), he describes his experiments on Turacine with the spectroscope, and states that the resemblance of its spectrum to that of cruorine induced him to test for iron. He adds that, on applying potassic ferro-cyanide to a solution of the ash of the pigment, "he was astonished that, instead of the deep blue of the ferric-ferro cyanide, the rich purple brown precipitate of the cupric ferro-cyanide was at once seen."—SEC. R. M. S.

Quekett Microscopical Club.*

At the ordinary meeting of the club, held at University College, May 28th, Arthur E. Durham, Esq., F.L.S., President, in the chair,—the meeting was made special for the revision of the bye-laws, and the various alterations proposed were read over and explained *seriatim*, and were adopted *nem. dis.* At the conclusion of the special business the minutes of the preceding meeting were read and confirmed, and twenty new members were unanimously elected; a number of donations to the club were also announced, and thanks returned to the respective donors. Mr. B. T. Lowne made an interesting communication relative to a specimen of a secretion from the stomach of a flamingo, which he exhibited under the microscope, and which had been obtained from a bird in the gardens of the Zoological Society. This secretion had recently been the subject of a discussion in 'The Field' newspaper, and from its resemblance to blood, together with the fact of its being made some use of in feeding the young, the ancient fabled mystery of the Pelican in the Wilderness feeding its young with blood drawn from its breast, here seemed to have met with a solution. From an examination of specimens of this fluid, the speaker was inclined to believe that it was not blood but a secretion, though, from the circumstance of the birds being found here under unnatural conditions, it might not be of a healthy character. Several instances were adduced of birds—the hornbills, bird's-nest swallow, &c.—being provided with similar secretions; and the curious fact of the passage of blood through membranes was referred to, some remarkable instances being quoted in which, under the influence of great excitement, it had been known to pass through the hides of Hippopotami and Rhinoceri. Mr. Lowne also drew attention to a very beautiful preparation of the brain of the larva of a blow-fly, showing clearly the imaginal [?] discs described by Dr. Weissman in 1864. Mr. W. W. Reeves made some remarks upon specimens of *Noctiluca miliaris*, which he exhibited alive; they had been obtained off Southend, and were amongst the results of a dredging excursion, to which some of the members of the club had been invited by Mr. Marshall Hall. Some further observations upon these creatures were also made by Dr. Braithwaite, Mr. Arnold, and Mr. Breese. Mr. Hislop called the attention of the members to a fine section of human brain which he exhibited, and which had been prepared by Dr. Dempsey. Mr. Johnson made a few observations upon the abundance of Melicerta and Stephanoceros at Finchley, and indicated the locality where they might be most readily obtained. The secretary read certificates in favour of eleven gentlemen who had been proposed for membership, and Mr. Curties placed upon the table two bottles containing a supply of Conochilus for distribution amongst the members. The President announced that during the ensuing month excursions would be made to Northfleet and Chiselhurst, also that the annual dinner of the club would take place at Leatherhead on June 23rd. The proceedings then terminated with a conversazione.

* Report supplied by Mr. R. T. Lewis.

Manchester Circulating Microscopic Cabinet Society.*

Quarterly meeting, held 13th April at the Lower Mosley Street Schools. Mr. R. Horne, President, in the chair.

The general business of the evening having been transacted, the chairman called upon each member, from a list previously prepared by the secretary, to exhibit the various slides of chemical crystals they had prepared since last meeting,—the slides of each particular crystal being shown under the several instruments and comments made thereon, before a new crystal was introduced; by which means the best forms were easily perceived, and the different modes of preparation and mounting were discussed whilst the objects were being viewed, thereby making the meeting more instructive and enabling it to pass off in a pleasant manner. The slides of santonine belonging to Mr. Horne, and those of a salt of aniline, belonging to Mr. T. Armstrong, were exceedingly pretty, and may justly be entitled the gems of that class.

Resolved unanimously that the subject for examination at the next meeting shall be "The Structure of Ferns." Each member to bring slides exhibiting the same, and what information he can gather on the subject.

Liverpool Microscopical Society.†

The fourth ordinary meeting was held at the Royal Institution on Tuesday, 6th April, Dr. Nevins, President, in the chair.

The secretary read a letter from Mr. T. C. White, M.R.C.S., on the forms assumed by the crystals of hippuric acid at various temperatures. Messrs. A. Kent and W. Chadburn were elected as ordinary members.

Mr. Newton exhibited a large number of slides sent by Mr. T. Wheeler, of London. The paper for the evening was by Mr. J. Newton, M.R.C.S.E., "On the Circulation in Plants and Animals." He dwelt on the fact that every living thing draws to itself its appropriate food, to supply materials for growth, to counteract the wear and tear of its tissues, for reproduction, &c. Whence arises a need for some special contrivance by which a complete circulation of the nutrient fluid through every part may be effected. Commencing with its simplest forms in the movement of the sap in plants, he traced it through the lower forms of animal life, until in the jointed worms, the annelida, we find a distinct circulatory system, consisting of two main trunks, a dorsal and a ventral, by the contractions of which the blood is sent through the smaller vessels. The various forms of circulation in the insect world, in the gasteropoda, as snails, and in reptiles, were next described. The necessity for the aëration of the blood in some form of lungs was dwelt on, whence arises the need for a pulmonic as well as a systemic heart, to send the blood thus purified through the body generally. It was shown that there are really two hearts in all the higher animals, separated in some, but blended apparently in many, as in man. The merits of Harvey, as

* Contributed by Mr. J. C. Hope, Hon. Sec., but not received by us till June.—Ed.

† Report sent too late for last Number.—Ed.

the great discoverer of the circulation of the blood, were dwelt on, and also of Malpighi, who first demonstrated it to the naked eye by means of the microscope. The lecture was illustrated by coloured diagrams, dissections, and living objects.

The fifth ordinary meeting was held at the Royal Institution, on Tuesday, 4th May, Rev. W. Banister, B.A., Vice-President, in the chair.

Bristol Microscopical Society.

May 27th, 1869. Mr. W. W. Stoddart, F.G.S., F.C.S., President, in the chair.—The minutes of the preceding meeting having been read and confirmed, and some other business discussed, Mr. W. J. Fedden, Vice-President of the Society, read a paper entitled "A Gleaning from the Float." The paper was a descriptive account of various organisms found by the author in the floating harbour at Bristol. He said it must not, however, be considered in any way as an account of the zoology and botany of the harbour, as he had not by any means worked out the subject so completely as he intended to do, and that, therefore, his present paper must be considered merely an instalment of more to come.

The following is a list of the various animals and plants mentioned by Mr. Fedden:—

Crustacea:—*Cyclops quadricornis, Talitrus,* ——— *sp.?*

Rotifera:—*Rotifer vulgaris, Brachionus,* ——— *sp.?*

Helminthozoa:—*Anguillula fluviatilis.*

Infusoria:—*Euplotes charon, Urostyla grandis, Stylonichia mylitus, Amphileptus anser, Amphileptus fasciola, Cothurnia imperbis, Cothurnia floscularia, Chilodon cucullulus, Epystilis digitalis, Carchesium polipinum, Vorticella patellina, Vorticella nebulifera, Vorticella convallaria, Stentor polymorpha, Stentor Mulleri.*

Diatomaceæ:—*Diatom tenue, Diatom elongatum, Diatom mesoleptum, Synedra tenuis, Synedra angustata, Surirella ovata, Bacillaria paradoxa, Melosira varians, Schizonema,* ——— *sp.?*

The author stated he had as yet been able to find scarcely any Desmidiæ or Algæ, and would therefore reserve them for a future occasion.

Brighton and Sussex Natural History Society.

June 10, Mr. Sewell, Vice-President, in the chair.—A paper was read by Mr. J. Robertson, entitled "A Narrative of a Recent Visit to the Volcano on Barren Island, near the Andaman Islands," which, though a very interesting contribution to science, contained nothing in relation to microscopical or histological research.

Maidstone and Mid-Kent Natural History Society.*

The first general meeting of the Maidstone and Mid-Kent Natural History Society was held on Tuesday afternoon (May 18th) in the

* The Secretary would much oblige us by in future forwarding a brief abstract of the meetings. The task of employing the scissors on a long newspaper report, which has on this occasion fallen to our lot, is not a pleasant one, and it takes up much time.—Ed. M. M. J.

Library at Chillington House, which had been kindly lent by the Museum Committee. The Society has only been recently established. It holds its meetings at 86, Week Street. The President is the Rev. J. G. Wood, M.A., F.L.S.; the Vice-Presidents, Dr. Monckton, A. Randall, Esq., Rev. D. D. Stewart, C. Roach Smith, Esq.; the Treasurer, Mr. H. Bensted; the Corresponding Secretary, the Rev. H. W. Dearden, M.A.; and the Local Secretary, Mr. J. H. Martin.

The chair was occupied by the President, Mr. Wood, and there was a good attendance of members and visitors.

The President gave a very interesting address. Mr. Carruthers then delivered an important lecture on "Some Fossil Cicads."

In the evening a conversazione took place, when some botanical and entomological specimens were exhibited, with a number of microscopes and a few scientific instruments. The circulation of blood in a frog's foot was illustrated, by means of the microscope, by Mr. Martin, one of the hon. secretaries.

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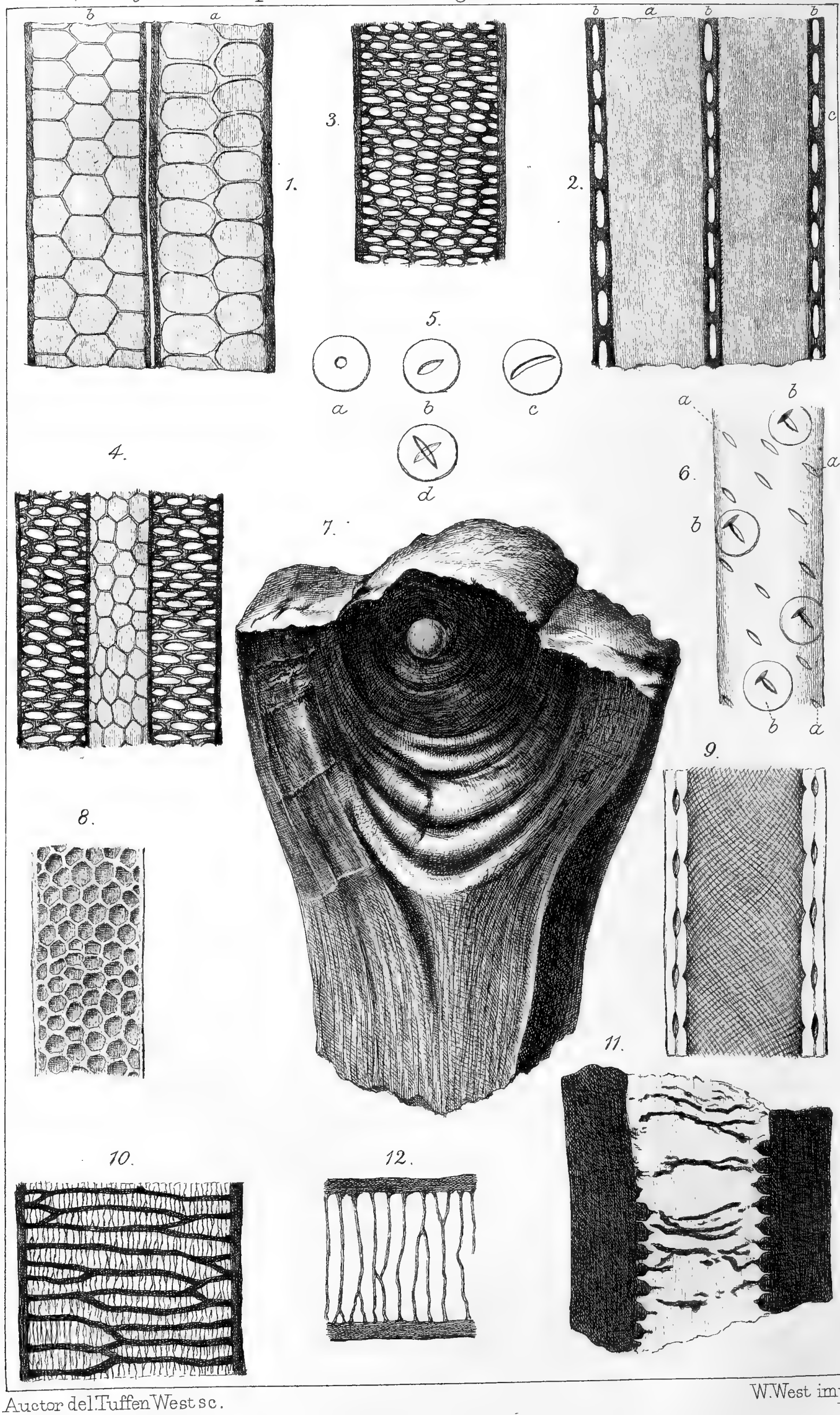


Auctor del. Tuffen West sc. W. West imp.

Exogenous Stems from Coal-Measures.

THE

MONTHLY MICROSCOPICAL JOURNAL.

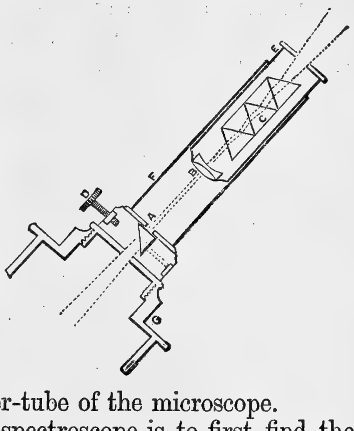
AUGUST 1, 1869.

I.—*On a Simple Form of Micro-spectroscope.*

By John Browning, F.R.A.S.

(*Read before the* Royal Microscopical Society, *June* 9, 1869.)

The instrument I have now to describe is substantially the same in its optical arrangements as that I had the honour of perfecting with Mr. Sorby some time since. As this instrument has been described in a paper I gave at the same time to the Society, I shall give but a very brief description of it on the present occasion.



The instrument consists essentially of a slit A, the width of which is adjustable by the screw D. An achromatic lens B, which focusses on the slit by sliding the tube E in the outer tube F F. A compound direct-vision prism C containing five prisms, and a small reflecting-prism P placed outside the slit A. This prism is for the purpose of throwing a second spectrum into the field of view for the purpose of comparison. The spectroscope is attached to the microscope by the adapter G, which fits into the drawer-tube of the microscope.

The best method of using this spectroscope is to first find the object in the microscope, and bring it to the centre of the field by means of an ordinary microscopic eye-piece. Then open the jaws of the slit by unscrewing the screw D. Remove the ordinary eye-piece from the microscope, and substitute the spectroscope in its place. The object should now show a confused spectrum through the jaws of the slit. On closing the slit and focussing carefully by means of the sliding-tube E, the absorption bands, if there be any in the spectrum, will become plainly visible.

I have been induced to arrange this simple and economical form

of micro-spectroscope at the earnest request of our excellent secretary, Mr. Hogg, who is of opinion that the price of the instrument previously has prevented its adoption.

II.—*On the Structure and Affinities of some Exogenous Stems from the Coal-measures.* By W. C. Williamson, F.R.S., Professor of Natural History in Owen's College, Manchester.

The generic term Dadoxylon, orginally introduced by Endlicher, has long been used in a vague manner by phytologists. It has been applied to a large number of woody stems, common in the Coal-measures, very few of which have any claim to rank in the genus. As defined by Endlicher and Brongniart, the genus is characterized by "les rayons médullaires étroits, simples composés d'une seule lame de tissu cellulaire;" and further, it has "les ponctuations des fibres ligneuses disposées en plusieurs séries alternantes entre elles, et prenant par pression la forme d'aréoles hexagonales." *

In 1851 I described the structure of some forms of Sternbergiæ,† and pointed out the apparently coniferous character of the woody zone surrounding the pith. I demonstrated the existence of rows of discs on the woody fibre arranged as in the living conifers; and concluded that the plants under consideration were true examples of Endlicher's genus Dadoxylon. Since the publication of that memoir, numerous specimens of woody stems have been found,

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EXPLANATION OF PLATE XX.

Fig. 1.—Vertical section of two fibres of Dadoxylon, from Coalbrook Dale.
" 2.—Tangential aspects of the same.
" 3.—Vertical section of part of a reticulated vessel of *Dictyoxylon Oldhamium*. Mr. Butterworth's cabinet.
" 4.—Tangential section of two vessels of the same, separated by a medullary ray.
" 5.—Varieties of discs from the vessels of *Cycas revoluta*.
" 6.—A vessel from the same.
a. pitted tissue.
b. glandular discs.
" 7.—Fragment of a stem of Dictyoxylon, reduced one-half.
" 8.—Reticulated fibre from a tangential section of *Araucaria imbricata*.
" 9.—Fibre from a tangential section of *Thuja Donniana*.
" 10.—Part of a scalariform vessel from the inner cylinder of a Lepidodendroid plant.
" 11.—Vertical section of a Dictyoxylon, showing the Sternbergian pith. Mr. Butterworth's Cabinet.
" 12.—Portion of Fig. 10 further magnified.

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* 'Tableau des Genres de Végétaux Fossiles,' par Adolphe Brongniart, p. 76.
† 'Transactions of the Literary and Philosophical Society of Manchester.'

transverse sections of which exhibit a structure identical with that of living conifers; but longitudinal sections show that the vessels or fibres are altogether different from the glandular or discigerous type. Instead of bearing rows of discs, and only on the surfaces of the vessels parallel with the medullary rays, their entire walls are covered with reticulations formed by the deposition of lignine *in the interior* of the vessels. All the specimens which have been latterly collected have been of this character; hence some of the most experienced phytologists came to the double conclusion that whilst the plants in question were true Dadoxylons, both Endlicher and myself had mistaken the internal reticulations of the fibres for the lenticular discs of true glandular fibre. Had this explanation been correct, we should have been left without any true coniferous wood in the Coal-measures. But it is not correct, as I shall now proceed to demonstrate.

Fig. 1 represents two fibres from my now celebrated specimen from Coalbrook Dale. The surfaces shown are those parallel to the medullary rays, and it will be seen that these surfaces are *entirely covered* in every fibre with discoid areolations. In some instances (Fig. 1, *a*) there are two vertical rows of these areolæ: the mutual pressure of their inner contiguous margins of which gives them a somewhat hexagonal form; but in other examples, as at Fig. 1, *a*, there is a distinct interval between the discs. In Fig. 1, *b*, we have three such vertical rows: the centre row, especially, having the hexagonal form to which M. Brongniart refers in his description of Dadoxylon. The only point in which these structures differ from the similar ones of living Araucarian conifers is the absence of the central dot in each disc. Of this I have never been able to detect a trace.

Fig. 2 represents two similar fibres as they appear in a tangential section of the stem. The surfaces (2, *a*) are here entirely smooth, being free alike from discs and reticulations. But between the contiguous fibres (2, *b*) we have a headed structure revealing the discs of Fig. 1, seen in section. The fibre-walls (Fig. 2, *c*) are very distinct, and afford the clearest proof that the discs are *external* to the fibre, as in recent conifers. There cannot be the slightest room for doubting that, whether the fructification of the tree was or was not coniferous, we have here a modification of true glandular or discigerous pleurenchyma. But if we turn to the more abundant examples of the so-called Dadoxylons, we shall find an altogether different structure.

Fig. 3 represents a fibre of the plant which Mr. Binney has designated *Dadoxylon Oldhamium*, and which, in the specimen figured, exhibits* the most magnificent instance of reticulated

* This specimen is from the rich cabinet of Mr. Butterworth, of High Crompton, near Oldham.

fibre with which I am acquainted. The fibres are unusually large, having constantly a diameter of from $\frac{1}{200}$ to $\frac{1}{400}$ of an inch. The reticulations cover the surface of the fibre, each areola being from $\frac{1}{1600}$ to $\frac{1}{2000}$ of an inch in diameter.

Fig. 4 represents part of a tangential section exhibiting the surfaces of two fibres parallel to the exterior of the plant. The fibres are separated by one of the large medullary rays, with its multiplied vertical rows of cells, and which constitute one of the striking features of this remarkable species. This section demonstrates what I have already affirmed, *viz.* that the reticulations cover equally the entire circumference of the interior of the tube, and are not confined, like the areola of coniferous fibres, to its lateral surfaces. These two figures represent reticulated fibres as seen in several distinct plants found in the Coal-measures. Whether these prove to be different species of one genus, or whether they will require more than one genus for their reception, remains to be seen. But certainly none of them can be regarded as Dadoxylons, since they belong to an altogether different type of structure. In the general *arrangement* of their tissues, whether of pith, wood, or bark, they correspond very closely with the true conifera, but we have no evidence that they were conifers.

Since these plants with reticulated fibres can no longer be recognized as Dadoxylons, they must either be assigned to some other existing genus, or have a new one instituted for their reception. The only existing genera which approach them are Palæoxylon and Pissadendron—the first of which was founded by Witham, and the last by Brongniart, for the reception of some of Witham's plants. All these are described by Brongniart as possessing true coniferous fibres, which, if correct, would exclude the specimens under consideration. It is possible that some of the former may belong to reticulated types—especially Palæoxylon—but, since they are not so defined by the founder of the genera, they must for the present be left amongst the conifers, though they may be doubtful ones.

It appears necessary, therefore, to establish a new genus for all the plants whose woody cylinders consist of reticulated fibres; and the name of Dictyoxylon appears an appropriate one for it. I should propose for the present to include in this genus *all* the reticulated types—whether their medullary rays consist of one or of several vertical series of cells. At some future time their further separation into two or more genera may be requisite.

I have already called attention to the fact that the hexagonal and almost circular discs of the fibres of Dadoxylon (Fig. 1) exhibit a plane surface, the central dot common in recent conifers being absent. The absence of this dot led the late Robert Brown, some years ago, to reject my conclusion, that the fibres in question

were of the coniferous type—neither of us at that time being aware of the demonstration that the tangential section would afford. I think I now see my way to an explanation of the absence of the dot. The question has a sufficiently important bearing upon the hypothesis of development of one tissue out of another, and, *pari passu*, of one plant out of another, to give it importance.

In studying the microscopic tissues of the Cycadeæ, I have for some time been convinced that the discigerous vessels in *Cycas revoluta*, usually supposed to be of a coniferous type, were in some measure modifications of scalariform tissue. I have now found numerous vessels from the above plant, which renders the fact certain, since they exhibit discigerous tissue at one end of the vessel, whilst it becomes scalariform at the other. My views on this point, when promulgated in private correspondence with some botanical friends, were at once rejected by them; but there is no reason for questioning their correctness. I was not aware, however, when I came to this conclusion, that I had been anticipated by the late Mr. Don, in a paper which he read before the Linnean Society in 1840. The question is of some importance, since it affects the possibility of a glandular coniferous fibre being developed out of a reticulated one.

There exists amongst geologists some misconception respecting the true nature of a glandular disc, which consists of two very distinct elements, *viz.* the circular or hexagonal areola and the central dot. The outlines of the former vary chiefly according to the mutual pressure to which they are subjected. The latter variously appear as a small circular dot (Fig. 5, *a*), an oblong one (Fig 5, *b*), which is sometimes so linear as to stretch across a great part of the disc (Fig. 5, *c*); and occasionally they assume a regular (Fig. 5, *d*) or irregular crucial shape (Fig. 6, *b*). The simple dot is due to a deficiency of the lignine lining the rest of *the interior* of the vessel, and is in no respect different from the pits of a pitted or porous vessel. But the circular disc or areola is external to the tube, consisting of a lenticular depression on the exterior of the wall of the fibre. That there is some connection between these two objects, when first formed, is obvious, from the constant presence of the dot in the centre of the areola, wherever the latter exists in recent plants. Thus the coniferous disc consists of two elements, one of which is internal to the primary wall of the vessel, whilst the other is external to it. The former may exist without the latter, as is the case in all porous or pitted vessels; but, as I have just observed, the latter never exists without the former, in the fibres of recent stems. Fig. 6 represents part of a scalariform vessel from *Cycas revoluta*, where the ligneous deposit has been so extended, that the oblique, transverse, thin spaces separating the bars of lignine, are reduced to mere oblong "pits" (Fig. 6, *a*), but where

the oblique parallelism of the original type of structure is still distinctly preserved. In this vessel a few of the pits are surrounded by an areola (Fig. 6, *b*), forming a true coniferous disc. In this individual fibre the addition of the areola is accompanied by a corresponding addition to the central dot, giving it an irregular crucial form, which does not exist in the "pits" that are not so furnished; demonstrating that the addition to the oblong dot converting it into a crucial one is external rather than an internal—such additions, however, are exceptional, though not rare. What causes determine the selection of special dots for areolation is uncertain; but we have here a manifest illustration of the process by which a spiral or scalariform vessel may be gradually transmitted into a glandular or discigerous one, and of the way in which the "pits" of the former structure regulate the positions of the discs of the latter.

It appears clear that in my Dadoxylon (Figs. 1 and 2) we have the outer lenticular disc, but not the internal deposits, converting the fibre into a pitted tissue. Hence the absence of the central dot in each areola, affording a new instance of the differences existing in the combinations of the elementary tissues in fossil as compared with recent plants, to which I have elsewhere called attention. In the stems of all the true conifers the discs are confined to the lateral surfaces of the fibres, parallel with the medullary rays—an arrangement to which those of Dadoxylon are no exception. I have observed that, in every recent conifer which I have studied, the "pits" opposite the discs (which are often converted into pores by the absorption of the wall of the vessel), also exist opposite each medullary ray, and there only, indicating some correspondence in the functions of the discs and the rays.

Whilst Dadoxylon thus appears to furnish the lenticular disc or external element of the coniferous fibre, I think we may regard Dictyoxylon as supplying a modification of the internal deposits, and thus possessing some relationship to the conifers. That the general aspect of the wood has been coniferous is shown by Fig. 7, which represents a specimen in my cabinet from the Lancashire Coal-measures. It is a portion of a large stem through which there passes a branch or "knot;" the undulations of the woody layers immediately below the branch too closely resemble those of a roughly-split pine-log to be overlooked. In the centre of the branch there appears a section of a rather large pith.

In estimating the true significance of the reticulated deposits of lignine in Dictyoxylon, we must recall the varied character of these internal deposits in recent conifers. They assume the simplest form in the common deal and other allied plants, where a continuous layer of lignine lines the tube, being wanting only, as already pointed out, opposite the glandular discs. In addition to this, in the common yew a second and more internal deposit exists,

in the form of a delicate spiral thread winding round the tube at wide intervals. In many of the Thujas and other Cupressinæ, an immense number of such threads line the previously thickened tube, and, running in opposite directions, cover its interior with a fine network. Fig. 9 represents a fibre of this kind from *Thuja Donniana.** A further advance is shown in an example of *Araucaria imbricata* which I examined some years ago, and of which I fortunately preserved a section, since I have never since been able to detect the same structure in other plants of this species. Many of the fibres exhibit the appearance represented in Fig. 8, a reticular deposit of translucent lignine lining their interior, closely corresponding with that of Dictyoxylon. This fact appears to me to have some significance in relation to the affinities of the Dictyoxylons; since it is the only instance in which I have detected a similar structure in a living conifer. Why I fail to find the same structure in other examples of this species I cannot discover. Having made the preparation myself, I know it to belong to the plant in question; besides which, its other features are identical with those of corresponding sections of this Araucaria which I have made more recently. Be the cause of this anomaly what it may, the specimen remains to demonstrate that, under some conditions, the ligneous deposits of the conifera assume a reticulate form. All the known modifications of reticulate vessels were long ago shown by Meyen to be modifications of the ordinary spiral vessels—a fact of which the fossil-plants of the Coal-measures afford ample proof. Figs. 10 and 11 represent a portion of a scalariform vessel from a Lepidodendroid plant from the Coal-measures, probably a Lomatophloros.† We here have a condition intermediate between the simple scalariform vessel and the reticulate one of Dictyoxylon. In this example there is a peculiar feature which I have observed both in young twigs and in old stems of the plant, *viz.* a number of delicate vertical lines of lignine, usually simple, less frequently branched, connecting together the contiguous transverse bars of the vessel. Fig. 12 represents a few of these vertical bands further enlarged. I am not aware that this very curious modification of the scalariform vessel has been hitherto noticed.

The examples quoted suffice to show how variable are the modifications of the elementary spiral fibre amongst living conifers, and the reticulations of the vessels of Dadoxylon present but one more variation of the same primary type. From this we may conclude that Dadoxylon and Dictyoxylon separately possess the

* I have found the same structure in some fossil stems from the Cretaceous beds of Missouri.

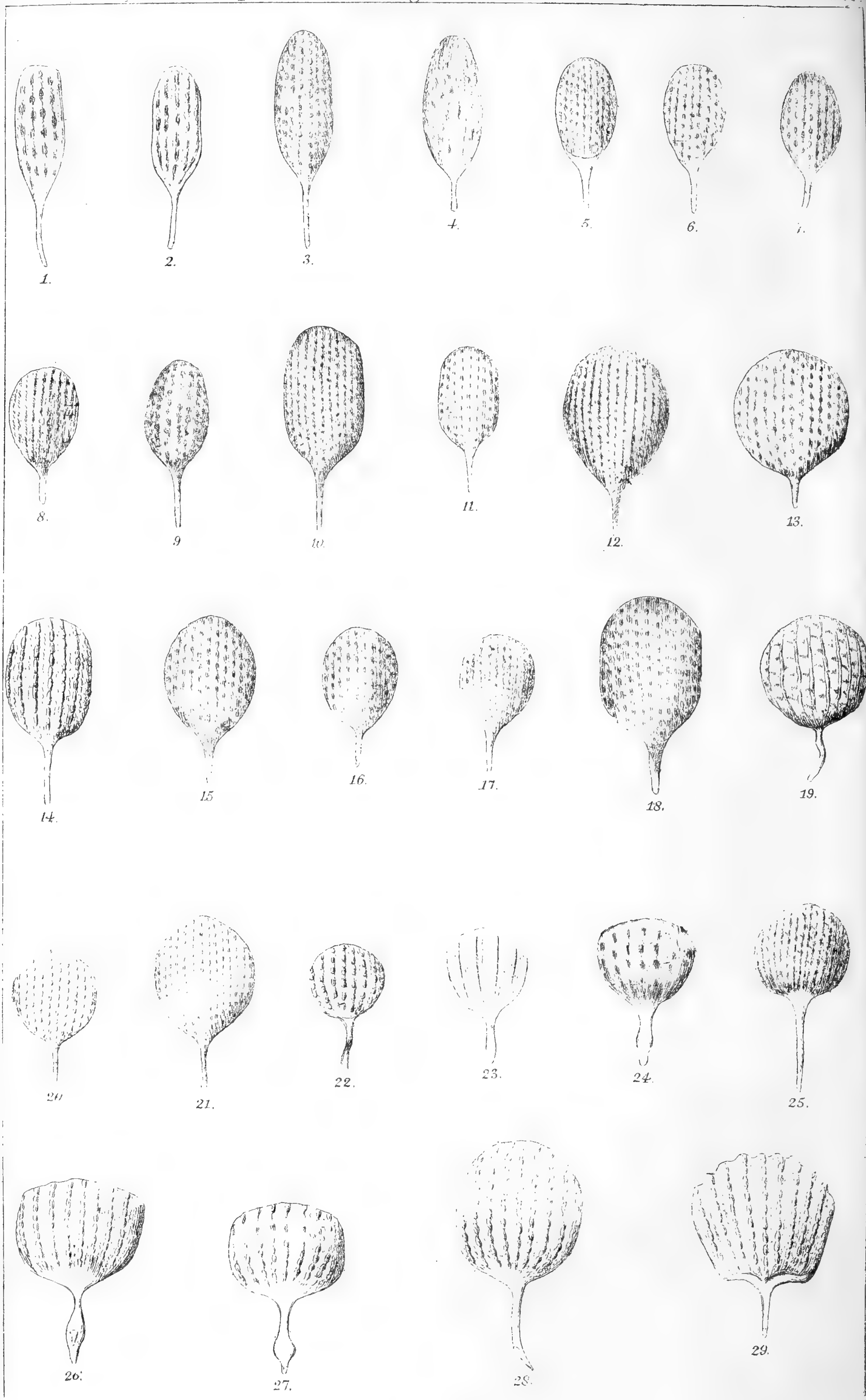
† This plant is evidently identical with that described by Mr. Binney in the 'Phil. Trans.,' under the name of *Sigillaria vascularis.* I am convinced that it was not a Sigillaria, but a form allied to Lepidodendron, as stated above.

two elements of external discs and internal deposits which, when combined, constitute the coniferous vessel. The Darwinian would find no difficulty in concluding that the pollen of one of these plants might fertilize the ovules of the other, and thus produce, at some later period, structures in which there combined the two elements that are severed in the vessels of Dadoxylon and Dictyoxylon.

It is evident that both the above genera possessed in some instances, if not in all, piths of the Sternbergian type. Fig. 11 represents a beautiful vertical section of a Dictyoxylon from Mr. Butterworth's cabinet—in which the Sternbergian pith is very well displayed—the discoid laminæ extending completely across the medullary cavity. This specimen is also remarkable for the regularity of the laminæ, as well as for the peculiar thickened aspect their section exhibits near the walls of the medullary space.

When we consider how abundant these large exogens—especially the Dictyoxylons—are in the Coal-measures, it becomes remarkable that we have hitherto been unable to identify either their foliage or their fructification. I cannot believe that the latter assumed the form of recent cones, or such would have been common amongst other Carboniferous fossils, because of the readiness with which such structures are preserved. This is shown by the abundance of Lepidostrobi in these beds. It seems to me not improbable that Trigonocarpon may have constituted the fruit of one of these genera. Dr. Hooker has already expressed his conviction that it was the fruit of a conifer allied to the modern Salisburia: from its abundance in many districts, it must have belonged to one of the more common trees of the Carboniferous period. This would point to Dictyoxylon, which is abundant in the Lancashire districts, where Trigonocarpons are common, as constituting the parent stem from which the latter had fallen.

I would observe, in conclusion, that I have very little confidence in any determinations respecting fossil plants, excepting such as are based upon *internal structure:* all the modern classifications of living plants rest upon this basis, and it is the only safe guide amongst fossil ones. Of course its indications require to be checked by considerations of external form; but the former must be primary, and the latter but secondary aids. We rely upon the former when the latter is not to be obtained, but only then.



Jos. Sidebotham, del. Tuffen West, sc. W. West, imp.

Battledore Scales of Lepidoptera.

III.—*On the Battledore Scales of Butterflies.*

By John Watson, Esq.

Plates XXI., XXII., and XXIII.

Some time since I communicated a series of papers on this subject to the 'Proceedings of the Literary and Philosophical Society of Manchester;' but as it would seem that the subject has been noticed by so few other observers, I am induced to recur to it in the pages of the 'Monthly Microscopical Journal.'

The scales of lepidopterous insects have long been subjects of microscopical examination; but it may be questioned whether sufficient notice has hitherto been taken of their peculiarities, with a view to the determination of the genera, species, and affinities of the insects, or of their systematic functions.

The ordinary scales are more or less oval, showing from two to five or more dentations at the broader end, and having a short, stiff, pointed peduncle at the other extremity, by which they are attached to the membrane of the wings. These scales are flat, like those of fish, and show striated markings. Referring to them in his 'Introduction to the Classification of Insects,' Westwood says, "Lyonnet has filled several quarto plates with representations of these scales, varying to almost every form, taken from the wings and body of the Goat Moth; so that the suggestion of a writer that the forms of these scales might be used for specific characters is entitled to no weight." (He likewise refers to a paper upon the same subject by a French author, presently to be noticed.) It appears probable that two or more different kinds of scales, serving distinct and separate offices, are to be found in lepidopterous insects; and this difference of function has not before been suggested.

In some genera of the diurnal Lepidoptera, besides the ordinary scales, some peculiar forms exist; and it is to these attention is now to be drawn, especially to those found in the genus *Pieris* and its congeners. Examination with the microscope shows that these scales are not flat, like the others, but cylindrical, or bellows-shaped, and hollow; they are attached to the wings by a bulb, at the end of a thin elastic peduncle differing in length in different species. The bulb also varies in size and shape; and there is a hole or indentation to receive it in the membrane of the wing, larger than that for the ordinary scale; and the whole apparatus has the appearance of a ball-and-socket joint, allowing considerable facility for motion or play. The scales are fixed to the wings at the broader instead of the narrower extremity, and there they are furnished with a fringe of cilia or hairs. The scales are placed on the upper surface of the wings, principally on the superior ones, with their tips projecting between the common scales; they are easily detached, and in removing them

the bulb is very liable to be broken off; they are much more numerous on some species than on others, and their number varies considerably even on individuals of the same species, especially at different periods of existence. The males alone possess them; none are ever found upon the females. They have been called "plumules" by some authors; and those of *Pieris Brassicæ, P. Rapæ*, and *P. Napi* (our common white garden Butterflies), are well known to microscopists, and were formerly called test-objects.

In the 'Annales des Sciences' for February, 1835, there is an interesting article on the organization of the scales of Lepidoptera, by M. Bernard Deschamps. It is principally devoted to the consideration of the structure of the scales, as composed of several lamellæ or membranes; of the mode in which they are affixed to the wings; and of the place in which the colouring matter is deposited. He also refers to these plumules, and gives figures of a few of them: he does not suggest any peculiar use for them, but draws attention to the fact that the males alone possess them, and that they have some general resemblance, with certain specific differences. He examined and figured seven species of the Pieridæ, to which family I am about to allude. My friend Mr. Sidebotham has most kindly and laboriously drawn the plumules of about one hundred species of Pieridæ observed by me, very few if any of which have been figured before.

According to the modern arrangement of Doubleday, Westwood, and Hewitson, the family "Pieridæ" consists of sixteen genera, and in seven of them, *viz. Euterpe, Pieris, Anthocharis, Idmais, Thestias, Hebomoia*, and *Eronia*, I have discovered plumules.* There are several distinct types of plumules, generally more or less running into one another; but each species possesses its own peculiarity, with diversity sufficient for identification, while in each individual of the same species there is always the same form of plumule. These, therefore, must afford to the scientific entomologist a valuable test in the determination of closely allied species, and it is probable that they may serve to form congenial natural groups and subdivisions in some of the genera.

It is remarkable that the peculiar and well-known plumule of *Pieris Rapæ* should prevail, in a generic and very similar form, also in *P. Napi, P. Cruciferarum*, and *P. Gliciria* (the first two European, the third North American, and the fourth Chinese). These insects are of close affinity in other respects; and in other instances congeniality of plumule is found in nearly allied insects.

The most remarkable and beautiful form of plumule, now for the first time observed, as far as is known to the writer or others to whom it has been shown, is that found on *Pieris Agathina*

* The examination extended over about 300 species; and I found plumules in all the male specimens, with three exceptions.

and *P. Chloris*, two West African Butterflies; and no approach to this form has been discovered on any others. The study of the actual objects with the binocular microscope and high powers will be well rewarded, and give abundant cause for speculation as to the absolute form of the plumules. They appear to be hollow membranous bags of a cylindrical or triangular shape, bound round by longitudinal ribs, which are curved inwardly, forming a contraction at about one-half or one-third of their length, where they are drawn in as by a cord. At the base, the ribs are inflexed towards the peduncle and bulb, to which they seem attached by the membrane. The large double-lobed transparent bulb, besides acting as a ball-and-socket joint, seems to serve as a valve to close the bag. Above the contraction, the ribs are continued with a curvature similar to the lower portion, and terminate in extremely fine and delicate points. In different specimens these approach more or less closely, and they appear to be free at the upper extremity, with a power of contraction or closing to protect the interior of the bag from the entrance of injurious matter. Their appearance is very much like that of the ciliated tentacula of the *Stephanoceros* or peristomes of some of the Mosses. The length of the bag is about 1-300th of an inch, without the peduncle and bulb, which, when fully drawn out, extend about 1-800th of an inch further beyond the point of attachment.

Next comes the interesting question concerning the function of these plumules in the economy of the insects, and the purpose they serve beyond that of the ordinary scales, which seem to act as the feathers of birds, in guarding the insects from wet, and supporting them in their flight—unless, indeed, they are not more nearly allied to the scales of fish. Reaumur and some other entomologists have supposed that the common scales, in addition to these ends, supply the tracheæ in the nervures of the wings with air, and that the striæ show the channels or air-passages; but after close examination of them with high powers, no external openings have been found fitting them for this purpose. The plumules, on the contrary, appear admirably adapted for air-vessels: they are hollow, and can be inflated like balloons, and have a tuft of cilia at the summit, which, by constant oscillation, may prevent hurtful substances from entrance, just as the cilia in the spiracles of many insects act. Through the bulb, which is valve-like shaped, being divided into two lobes, there may be communication with the tracheæ. The plumules may thus perform a double function, conducting a supply of air to the nervures of the wings, and, when inflated, adding considerably to the buoyancy of the insect. Besides, from the manner in which they are placed, partly between and partly under the ordinary scales, the latter must be raised when the former are inflated; and when not in use, they probably lie

flat, like empty bags, under the superincumbent scales. By this supposition, as regards the functions of these plumules, we may account for the superior strength and power of flight which the males possess over the females.

Here, then, is a field open for great microscopical research—a field which promises variety of interest the further it is pursued. New forms of scales will probably be discovered in many genera hitherto unexamined; the attention should not, however, be directed solely to the observation of these plumules, as all the forms of scales are worthy of careful study.

In the following families I have found no plumules, *viz.* Papilionidæ, Acræidæ, Morphidæ, Brassolidæ, Eurytelidæ, Libytheidæ, and Hesperidæ. In the Danaidæ I have found them only in the genus *Euplæa*. In the Heliconidæ only in the genus *Heliconia*, unless *Eueides* is to be considered as belonging to this family, and not to the Nymphalidæ, which position is justified by the form of the plumule. In the Nymphalidæ I have found them in several genera, principally of the *Argynnis* group; and notably in *Athyma*, but not in *Neptis*. In the Satyridæ in several genera, and the well known scale of *Epinephele Janira* is a good type of the generic form.

And now passing to the Lycænidæ, I beg to refer to the battledore scales (so called) which are represented in the accompanying plates. They seem to be intended to serve the same office as the plumules in other families, whatever that may be. They exhibit similar generic and specific alliances and differences, and answer the same purpose of identification of species.

They are most beautiful microscopic objects, and interesting in a physiological sense, displaying how variously and marvellously creative power has worked in these minute organisms, always with the same end in view.

The especial function of the plumules of the Pieridæ has been suggested by me to be that of air-vessels, giving buoyancy to the insects; and these Lycæna scales, by their balloon shape, are eminently fitted for this service, and even in a greater degree render it probable that certain Lepidoptera possess at least two kinds of scales, performing different offices in the economy of the insects. These plumules are attached to the wings by an apparently hollow peduncle. They show striæ-like ribs, suitable for binding, strengthening, and distending or contracting their balloon-like forms; these ribs are more or less beaded or articulated, by which different scales are bound or bent in various ways. The end opposite to that of insertion is closed or covered with apparently ciliary apparatus. And they lie in rows between and under the ordinary scales, which may therefore be elevated or depressed at the pleasure of the insects by the regulated inflation of the plumules. They differ in separate species in every conceivable way—in form, in the number and

articulation of the ribs, in transparency, in size, and in the length and shape of the peduncle; and among them are found some very anomalous forms, as in the plumules of the Pieridæ. In that family, *Pieris Agathina* possesses an abnormal and unique form; and so in the Lycænidæ, *Lycæna bætica* resembles it in this peculiarity.

And as in the Pieridæ, so in the Lycænidæ, it is only on the males that these scales are found; it is probable that this mark of virility may indicate the comparative vigour or age of the insects. On some individuals of the same species they are much more abundant than on others; and, again, in some species they are plentiful, and in others scarce; and in some individuals of all species it is difficult to find them at all. On newly-caught specimens, however, they are most easily found.

It is the genus *Lycæna*, with its neighbour *Danis*, which affords the scales now submitted to inspection in the plates. The upper-side of the wings of the males is generally bright blue, but at all events with more or less blue irrorations; the males of certain species, however, are brown. The females are generally brown; but even when they have blue surfaces, I have found no plumules on them; while on the males which have any tinges or reflexions of blue, these scales are present. No species, however, the males of which are brown, yields these scales; and yet it is not in these peculiar scales that the pigment or colour-reflexion resides. To a very eminent lepidopterist I some time since wrote, asking if he was aware of any other physiological difference between the blue and brown species. His reply was, "that he could not think there was any other difference, but that it was a most interesting fact that when these males imitate the females in colour, they lose another male characteristic."

Mr. Sidebotham has, with habitual industry and kindness, drawn figures of a large number of these scales; and some are represented in the accompanying plates. These drawings are as truthful as beautiful; the slides were mounted from insects in my own cabinet, and I believe reliance may be placed on the correctness of the nomenclature and habitat.

Nos. 1a, 40, 42a, 46, and 50, belong to the genus *Lycæna*. 47, 48, 49, 52, and 53, belong to the genus *Danis*, according to the arrangement of Doubleday, Westwood, and Hewitson, in their 'Genera of Diurnal Lepidoptera,' the text-book of general diurnal lepidopterists. The under-sides of the insects of this genus are unlike those of *Lycæna*, but have a family resemblance of their own. In constituting this a genus, our authors say of it, "With general characters of *Lycæna*, it appears very (perhaps too) close to *Lycæna*." This is said without reference having been made to other than the usual tests. The scales have certainly a peculiarity of their own.

The remarkable figures 38 to 41 cannot fail to attract attention; and at first sight it would be thought that they can have no

relation to the others, and that the insects could have no natural affinity; but similar differences (inconsistencies, if you will) exist in the Pieridæ, and it does not appear that insects nearly allied in other respects are always furnished with similar plumules. It is, however, possible that similarity in this respect may hereafter influence entomologists in their arrangements.

The scales represented by Figs. 1 to 37 and 42 to 53 are from insects inhabiting various localities all over the world, each with certain geographical limits. Most Butterflies have a rather narrow range of habitat, as is the case with other animals; and some are confined to very strait localities. For example, *Morpho Ganymede* is known only as inhabiting a certain district of Bogota, the family Acræa is found almost only in Africa, *Ageronia* only in Brazil; but *Pyrameis cardui* ranges over the whole world, and *Vanessa Antiopa* is excluded only from Africa. Now *Lycæna bætica*, Figs. 38, 39, and 40, is also a cosmopolite, inhabiting all the localities of those represented in the Plates. In the 'Diurnal Genera,' before referred to, its habitat is given as "Southern Europe, Java, South Africa, Mauritius, Madagascar, Africa, India." It has also been found in Great Britain; and I may add to the list Australia, the insect from which Fig. No. 40 was taken having been captured by Mr. Diggles at Moreton Bay. Figs. 38 and 39 are also from Moreton Bay, and mere varieties of the same insect.

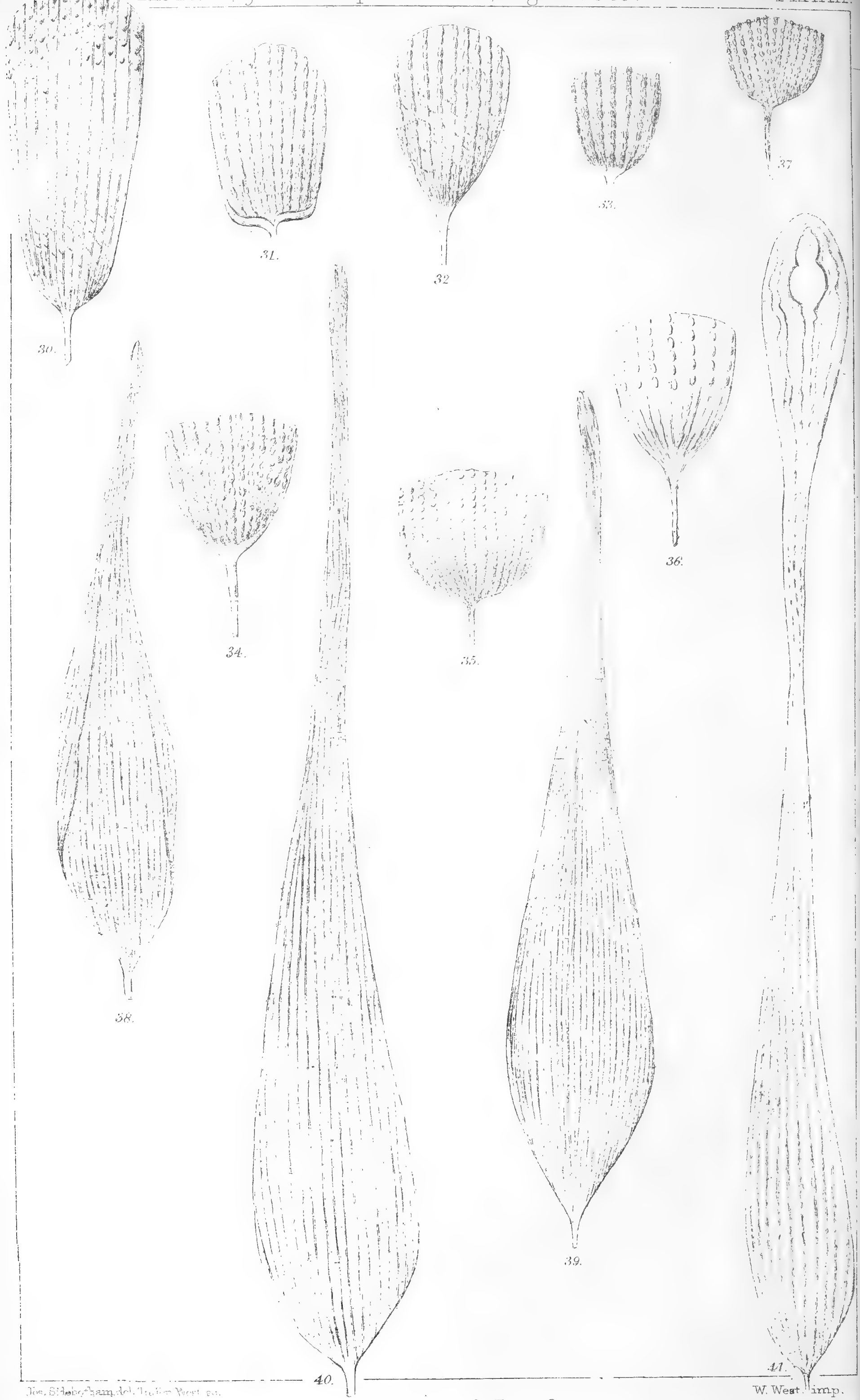
Collectors are now receiving from Australia insects previously known as appertaining only to the Indian Archipelago; and it is remarkable that while this island has an insect fauna of its own, it should also possess the insects of neighbouring though distant lands, and yet that its peculiar fauna, animal and vegetable, should be distinct.

The insect whose scale is shown by No. 41 has been lately named by Felder *Dipsas lycænoides;* it is questionable whether it should be placed in the genus *Dipsas.* It is also from Moreton Bay, and evidently allied to *bætica.* The beaded or articulated appearance at the upper end is very singular. The insect has an evident affinity with *bætica*, but in no other instance have I found any scale approaching these.

The points desired to be insisted upon as useful in this investigation are—

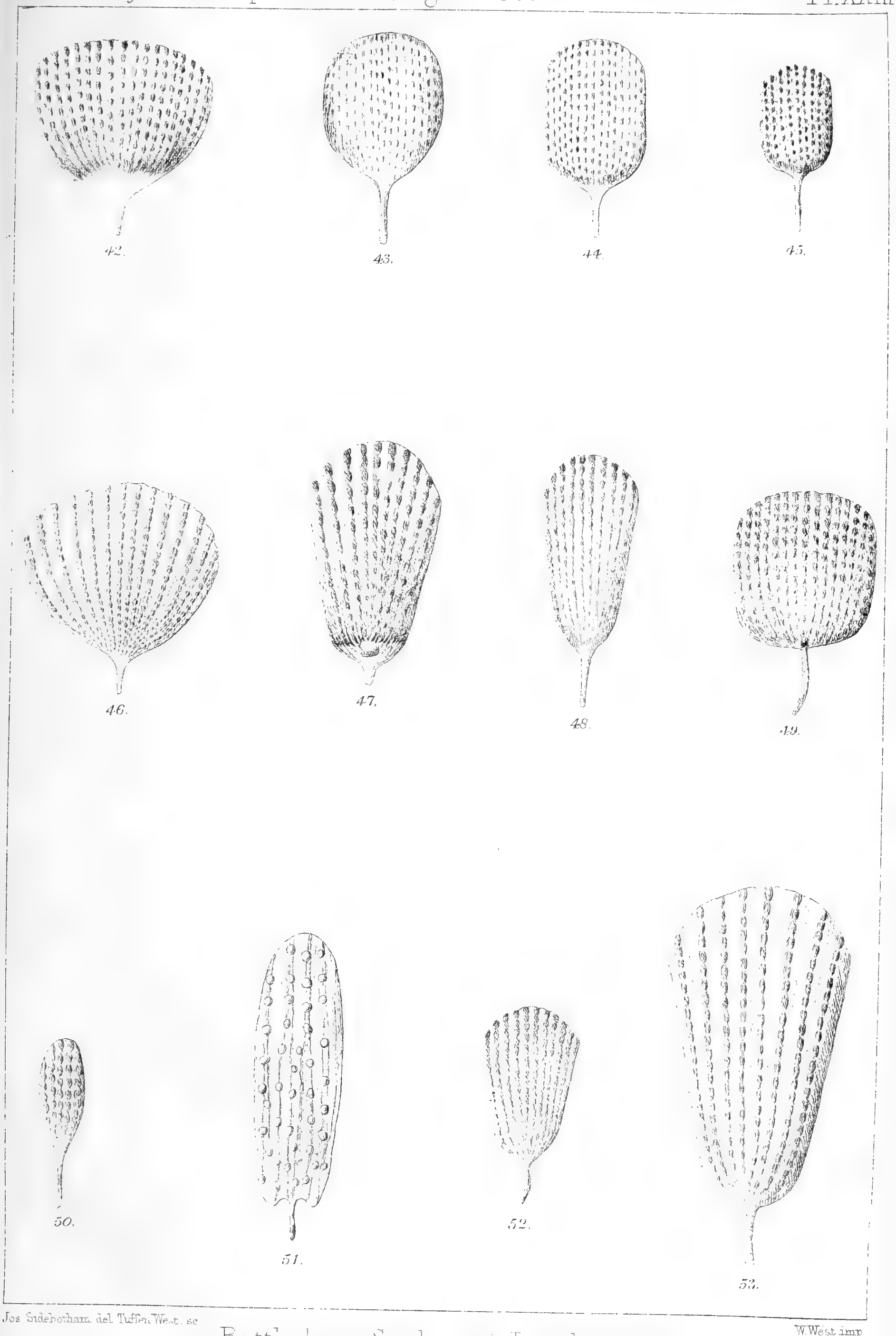
1. That these plumules are always identical in different individuals of the same species; and therefore mere geographical or other varieties may be detected by this test; and that

2. In species nearly allied, so closely as to make them difficult of distinction, these scales will be often found very different, forming very certain and unquestionable divisions; while, on the other hand, species of easy separation in other physiological peculiarities have sometimes almost identical plumules.



Jos. Sidebotham del. Tuffen West sc. W. West imp.

Battledore Scales of Lepidoptera.



Jos. Sidebotham del. Tuffen West. sc. W. West imp.

Battledore Scales of Lepidoptera.

Microscopists have seen in some of the Foraminifera exquisite forms of flasks and decanters; and in these plumules no one can fail to observe their elegance, beauty, and applicability to industrial-art purposes for forms and engravings of wine-glasses and goblets.

The following is a list of the names and habitats of the insects to which the plates have reference:—

EXPLANATION OF PLATES XXI., XXII., AND XXIII.*

LYCÆNA.

Fig. 1. Alexis. Europe.
„ 2. Icarius. „
„ 3. Dorylas. „
„ 4. Damon. „
„ 5. Adonis. „
„ 6. Acis. „
„ 7. Ægon. „
„ 8. Cœlestina. „
„ 9. Corydon. „
„ 10. Orbitulus. „
„ 11. Theophrastus. India.
„ 12. Alsus. Europe.
„ 13. Euphemus. „
„ 14. Melanops. „
„ 15. Unknown, and not named.
„ 16. Sebrus. Europe.
„ 17. Argus. „
„ 18. Unknown, and not named.
„ 19. Do.
„ 20. Optilete. Europe.
„ 21. Hylas. „
„ 22. Cassius. Brazil.
„ 23. Unknown. India.
„ 24. Telicanus. Africa.
„ 25. Unknown.
„ 26. Do.
„ 27. Do.

Fig. 28. Methymna. Cape Town.
„ 29. Ælianus. India.
„ 30. Elpis. „
„ 31. Celeno. „
„ 32. Erebus. Europe.
„ 33. Kandarpa. India.
„ 34. Argiolus. Europe.
„ 35. Unknown.
„ 36. Pseudargiolus. Canada West.
„ 37. Unknown. Australia.
„ 38. Do. „
„ 39. Do. „
„ 40. Do. „
„ 41. Dipsas lycænoides. Australia.
„ 42. Lycæna cardia. India.
„ 43. —— Lacturnus. „
„ 44. —— Aratus. „
„ 45. —— Cneius. „
„ 46. Unknown. „
„ 47. Danis Hylas.
„ 48. —— new species.
„ 49. —— „
„ 50. Lycæna Alexis.
„ 51. ——? new species.
„ 52. Danis, new species.
„ 53. —— Sebæ.

IV.—*On the Microscope Prism and the Structure of the Podura Scale; being a Postscript to the Paper "On the Diatom Prism and Diatom Markings," read before the Royal Microscopical Society, June* 9, 1869. By the Rev. J. B. Reade, M.A., F.R.S., President of the Royal Microscopical Society.

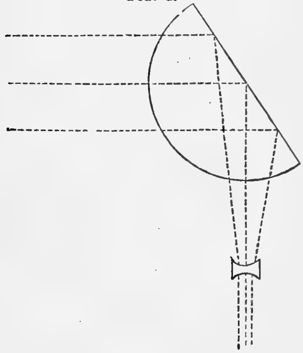
THE paper on the Diatom Prism contained an account of the nature and effect of the illumination as illustrated by the development of Diatom Markings. These were new to me, and at none of our meetings, either public or private, had I ever seen any exposition of

* We here beg to acknowledge most gratefully the extreme courtesy of the Council of the Literary and Philosophical Society of Manchester, by which we are permitted to reproduce the beautiful plates from its Transactions, in illustration of Mr. Watson's paper.—ED. M. M. J.

the surface of the valves which led to any definite and exact knowledge of the structure. In the short discussion on the paper, in which, by perhaps unavoidable circumstances, I was prevented from taking a part, it appeared that some microscopists had for years "considered the markings to be spherical." Here, no doubt, an erroneous method of illumination, though incapable of suppressing the whole of the truth, was yet insufficient to reveal "nothing but the truth," and hence Mr. Slack very naturally distrusts the usual mode of displaying diatom valves.

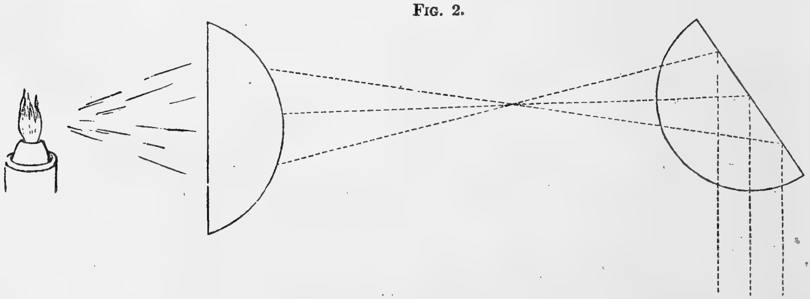
By breaking up a valve of *P. quadratum*, Mr. Wenham had obtained single spherules, and had also detached a line of spherules like a row of beads; but this most conclusive evidence still fails to convince some observers that the law of Diatom structure is established. It is more than probable, however, that their doubts will be set at rest by the single pencil of parallel light reflected from the equilateral prism.

FIG. 1.



Since the paper was read, I have used the upper crown-glass hemisphere of the kettledrum as a Brewster's hemispherical prism, in which, says Brewster, the two convex surfaces are ground at the same time; and Mr. Ross made a deep double concave flint lens, which is so placed within the converging cone (Fig. 1) as to render the emergent rays both parallel and achromatic. In practice, however, I find it easier to obtain parallel light by placing the lower hemisphere of the kettledrum, or any bull's-eye lens, between the lamp and the hemispherical prism (Fig. 2), and allowing the rays,

FIG. 2.



after crossing at the focus, to fall upon the plane surface of the prism. These diverging rays are just sufficiently shut up by the converging power of this prism as to be rendered parallel when

reflected on the object under examination. Virtually, the point or source of light is in the principal focus of the prism, and the reflected rays are of course parallel. We thus obtain great intensity of illumination, which may be useful in the examination of certain structures, and the little vivid disc of light is easily thrown into the centre or on any part of the circumference of the field; but hitherto the plane prism has answered every requirement in the examinations I have made, and of these one of recent interest has been the scale of the *Podura.*

In the interpretation of this standard test object—the Podura scale—the value of parallel light from one source of light only will, I think, be admitted by all observers. But those who are about to use it must expect to see what they have never seen before; for I can truly say with Mr. Wenham, whose results on a dark ground are a very close approximation to my own results on a light ground, that "this appearance is so different from anything before seen in the *Podura,* that were I to exhibit it as such, not one of its numerous friends would recognize it." It is no slight satisfaction to feel that the support of so high an authority as Mr. Wenham will tend to make *a priori* objectors cautious. Mr. Wenham's paper is published in the 'Monthly Microscopical Journal' for July.

The following description is accepted by friends who have worked with me. The scale of the Podura consists of two membranes, between which there is a series of small solid spherules. These spherules or beads are often arranged in parallel rows towards the edge of the scale, and in the centre they are placed rather diamond-wise. Under a power of 12,000 linear, I have found 24 spherules in $\frac{1}{1000}$th of an inch on the 12-inch horizontal diameter of the field and 6 on the vertical diameter. Hence, in the latter direction they are about $\frac{1}{6000}$th of an inch apart, and in the former, the interval being equal to a diameter of a spherule, they are about $\frac{1}{48000}$th of an inch apart. If now we could place a series of spherules in almost close contact on the vertical diameter, we should have parallel rows of about 48 spherules enclosed between the membranes as in a tube, and the membranes themselves would touch and be in close contact along the parallel intervals. Now let this close contact of the membranes continue, since in point of fact it really does exist on the scale, but remove the spherules we have supposed to be inserted. Then we have an empty space like the empty finger of a glove between spherule and spherule on the vertical diameter of the field. The sides of this tubular space cannot preserve their parallelism without the support of the supposed additional spherules, and therefore they tend to fall together, having the diameter of the existing spherule for the width of the tube close to the spherule, and thence tapering to a point just before a lower spherule is reached. Thus we have on the vertical 12-inch dia-

meter, under a power of 12,000 linear, a set of 6 spherules at the top of 6 *hollow cones of membrane*, which may be shown as brilliant objects on a dark ground, while at the same time they naturally prevent the *direct* light of the usual achromatic condenser from passing through them. If this is the true interpretation, and I believe it to be so, it is a curious fact that simple darkness in the hollow cones—the absence of light and not the presence of shadow—supplies our skilled opticians with their best test in the shape of "a note of exclamation," having exquisite definition and *apparent* materiality. But if, instead of using direct light, we so place an equilateral prism as to throw a parallel beam of oblique light along the length of the scale, the shadow of the raised membrane which forms the hollow cone disappears, and we immediately get rid also of the interior darkness, and therefore of all trace of "exclamation" except that which almost naturally arises at the now novel sight of nothing but small spheres upon what we know to be a scale of the Podura! The object seems to be—as by Mr. Wenham's method it really is—illuminated from above, and the "*bright blue circular spots*" of Mr. Wenham are seen by transmitted light and natural shadows to stand out in full relief as distinct spherical bodies. These spherules may often be distinctly seen on the margin of the scale, and in more than one instance I have seen them as detached bodies near the scale.

Among the "variety of modes of illumination" alluded to by Mr. Beck, there are no doubt some which are calculated to mislead us; but the equilateral prism is a safe guide, and much information respecting the structure of the Podura scale may be readily gathered by throwing the parallel beam of light in various directions on its surface. Most of the peculiar characteristics pointed out by Mr. Wenham become apparent, as well as the new features above described; and, notwithstanding the difference in our modes of examination, we come to the same conclusion that the markings are "not real spines," but "so incorporated with the membranes that separation cannot be effected."

The equilateral prism which I used in the first instance for supplying a single pencil of parallel light is 5 inches long with one-inch faces. It was made about thirty years ago of the well-known white sand which abounds in my old parish of Stone. I now use with equal effect and easier management much smaller prisms of an inch and even half-an-inch in length, with inch and half-inch faces. Mr. Ross has adapted these prisms to my microscope, mounted on a small arm with ball-and-socket joint. In a *popular instrument* the expensive luxuries of a mechanical sub-stage and elaborate condensers may be dispensed with, and the *Prism Microscope*, consisting of the body with its powers, a thin stage, and a two-inch equilateral prism, will look like a good working tool, and

cannot fail to interpret the minute wonders of Creation to many intelligent admirers of Nature.

P.S.—July 21.—In consequence of a question just put to me by one of the early Fellows of our Society, the Rev. Charles Pritchard, between whom and myself the microscope was in years long gone by a bond of union, I find it necessary to add a few additional remarks. The question is, "How does the *prism*, as such, effect the work better than a good plane surface?" Before answering the question I thought it better to examine the quantity and nature of the light which is reflected up the tube of the microscope from the left-hand plane face of the prism—an angle of the prism being towards the object on the stage—and the same light which passes through the same face of the prism and is totally reflected up the tube from the adjacent face or base of the prism, by turning the prism a little on its axis, the prism lying nearly under the vertical diameter of the stage. My report may "sound like a fable," but nevertheless the difference is marvellous. The whole light of the lamp totally reflected is not perceptibly altered either in nature or quantity, but the portion reflected from the face, and not entering the prism, is a *purely polarized beam!* As such I have used it in the examination of several suitable objects, passing it through selenite plates where necessary, and I prefer the results to any previously obtained by the direct light of a common Nicol's prism. Salicine and crystals generally, as well as fine vessels in animal and vegetable tissues, are seen in almost stereoscopic relief, in consequence of the shadows which are readily thrown by a slight obliquity of the polarizing pencil. This obliquity may be extended to the bringing out the effect of polarized light even on a dark ground, and thus, as in the combination devised by Mr. Furze, heightening the solidity by the play of colours.

The plane prism may be used in other instruments as a polarizer, but it is satisfactory to find that the prism microscope is independent of extra appliances for producing polarized light.

I will only add, that when the sun itself is reflected from a surface of the prism, its disc being seen at the bottom of the tube, the phenomena of polarization, so easily exhibited, are brilliant in the extreme. The eye, also, is not fatigued by the brightness of this one component part of the sun's light; but the whole light totally reflected from an inner face of the prism would be intolerable. The brightness of the polarized beam may, however, be diminished to any extent by simply placing small pieces of white linen of different thicknesses between the prism and the sun.

The plane speculum of a Newtonian Telescope exhibits less polarization, both with daylight and lamplight, than the plane

surface of an equilateral prism, but far too much to allow it to take the place of the prism which alone supplies a beam of pure unpolarized light at the angle of total reflexion.

V.—*On Methods of Microscopical Research.* By Herr S. Stricker.*

The microscope is an implement of research. When objects are too small to give, at the necessary distance from the eye, a sufficiently large image on the retina, they require a simple or compound microscope for their investigation. But the field over which the investigation ranges is not determined by the employment of such an instrument. Microscopy denotes not a doctrince but a method of investigation, the most delicate indeed of its kind for terrestrial objects, for our microscopes now are the most perfect of optical instruments.

The most extensive use has hitherto been made of the microscope in the investigation of organisms. The knowledge of the more minute structure of the tissues of the vegetable and animal body, and especially of the latter, has been raised to an independent science, which branches again into important subdivisions. Normal tissues, and those altered or produced by abnormal influences, form already the basis of two distinct—though very intimately connected—sciences, and either may again be considered from two points of view. We occupy ourselves with the morphology or the biology of tissues, or, as it may be also expressed, the normal or pathological anatomy, or the normal or pathological physiology of tissues. Morphology and physiology of tissues are, however, so intimately related to each other, that we cannot now think of a separation of the two. The observation of the vital phenomena of tissues, and experiments with them, will lead us to a large knowledge of their most intimate structure, whilst, *vice versâ*, a research into their structure will facilitate our conclusions in regard to certain vital phenomena.

The methods which have been applied in these two departments are different. To watch the vital processes under the microscope, and then to influence them, require other means than those which are necessary for acquiring a knowledge of only the forms of the elements of the tissues. Besides, experiments under the microscope upon living objects are of a different nature from those upon dead ones. The sensitiveness of the former to external influences renders, in even

* Translated from the 'Handbuch der Lehre von den Geweben.' Leipzig: Engelmann, 1868.

the microscopically small space of the instrument and under the necessary conditions of its employment, experiments possible which would be out of the question with portions of dead tissue. Slight changes of temperature, feeble electric currents, and weak acids are sufficient to induce changes in living tissues. But if experiment is to be made upon dead tissues, then more powerful influences are required than the delicate instrument or the observer stooping over it are always able to endure. The greater sensitiveness of living organisms renders very delicate manipulation necessary, but at the same time it facilitates experiment. To this also must it be ascribed that only of late years has the latter fact been more largely recognized, namely, about the time when the investigation of living tissues became more extended.

The tissues may be examined either by the light which they reflect from their surface, or by that which they give passage to—indirect or transmitted light. In direct light every object may be examined, provided it receives and reflects light enough, and that both object and microscope can be fixed.

It is self-evident that the instrument must admit of being focussed, otherwise it will not be possible to obtain well-defined retinal images in all the cases coming under examination. Great enlargement must be dispensed with in direct light, because the distance between the objects and the lens must here be small ; so that strongly magnifying lenses cover the object and interfere with its illumination. It is, however, possible to apply illumination on the principle of the ophthalmoscope, and then the difficulty indicated is overcome.

The investigation in reflected light gains very much by direct illumination, or, what is still better, if a focal image of the source of light is thrown upon the place of the object to be examined, details will then often appear which can scarcely be observed in diffused daylight.

If longer distances are required in the examination by direct light—as, for example, when we work under the microscope with larger instruments, or when objects have to be viewed or prepared under liquids—Brücke's magnifier will be found serviceable. This is put into the arm of Nachet's or Hartnack's stand, and the object placed upon the stage. Focussing is then effected with the unaided hand by moving the magnifier. This combination is of great service in the case of delicate preparations with needles, such as the isolation of ganglion-cells, or the exhibition of minute fibres. There the objects are in every case placed upon an opaque ground —on an opaque grey ground if the object is dark; on an opaque black ground if the object is clear. The object to be dissected out can, in every case, be placed upon a glass plate, and under this a dead white or black slip of paper, as the case requires. For the

examination of a larger fragment of tissue in fluids, small capsules should be used, which rest upon a flat base, and have a spheroidal cavity, somewhat like the saltcellars in common use. An opaque dull ground may easily be obtained by coating the surface with a thick layer of coloured wax or gutta percha. At the same time a basis is thereby gained to which the objects may be fixed with needles.

If it is a matter of importance to get a view of the objects in strong relief to see the details on their surfaces, then the magnifiers of Steinheil of Munich are especially to be recommended; but it is advisable that they should be supported by a ball-and-socket arm, which can be moved both horizontally and vertically on a fixed stand; if forceps and scissors are to be used in making a preparation under a high magnifying power, then the capsule for the preparation should be placed upon a blackened block of wood, several centimètres high and resting directly upon the table. In such cases preparations are made more safely if the arms can rest upon the table in a position nearly horizontal. In working under powerful magnifiers, the nose of necessity comes nearly in contact with the preparation, and the bridge of the nose may then be made use of as a support for the cutting instruments employed. The preparation with scissors and forceps under strong powers requires, as a rule, a very great steadiness and a very exact guiding of the cutting instrument, and it is almost indispensable to support it somewhere when a careful dissection has to be made of small and delicate objects. When the left eye is applied to the lens the right hand can direct with great safety a pair of scissors balanced upon the bridge of the nose, whilst the other hand fixes the object. In fixing any delicate objects, heavy forceps should be made use of with fine but not roughened points.

In working by direct light with compound microscopes only, the lower objectives, as far as No. 5 of Hartnack's microscope and the corresponding ones of other instruments, can be used. For making preparations compound microscopes of low power were formerly employed, in which the image was erect or had the same direction as the object.

These so-called dissection-microscopes can be easily dispensed with, since one very soon gets accustomed to the inverted images as regards the inverted guiding of the hands.

Investigation with transmitted light can likewise be undertaken with both simple and compound microscopes. As regards the use of the former, we can add but little to what has been said before.

When an investigation is to be made in transmitted light, the support must of course be transparent, and the object must be illuminated by a reflexion apparatus, placed below it, in the form of either a prism or a mirror. Simple microscopes, or the low powers

of compound ones, are only employed in transmitted light when it is required to ascertain the general forms and relations of the tissues. The larger the object is the lower must be the magnifying power, if it is desired to give a complete view of it. In the case of larger objects, however, a general view is taken with a low magnifying power, and then the details are studied by going over them with a higher power. The very powerful lenses recently manufactured by Hartnack serve chiefly for the examination of living tissues, or of isolated, well-preserved tissue elements. In tissues which have been, for the purposes of investigation, submitted to rough treatment—which have been, that is to say, hardened by reagents, coloured and repeatedly washed—a high magnifying power brings out at first sight little more than those of average power; indeed the eye less skilled can see in such cases less clearly, when using Hartnack's No. 15 than when using Hartnack's No. 8. But high magnifying powers are even here an invaluable aid for the beginner when the definition of deep structures is required. It is necessary to use the screw with the greatest caution and to turn it only very slightly, so as to obtain after each slight turn of the screw a new field of vision on which to rest, and observe whether to proceed next to a deeper or higher one, to advance or withdraw.

When we have to do with isolated and particularly well-preserved elementary forms; and further, when the preparations are examined when recent and without the addition of fluids, or of such only as do not affect them, the greatest advantage is derived from the use of high magnifying powers. The advance in our knowledge of the cell and of the finer structure of the nerve-fibre rests upon investigations with the excellent instruments of modern construction. The examinations of the cornea in the living state, as they were commenced by Recklinghausen and Kühne, must convince us more completely of the value of high magnifying powers. It is indeed true that the structure of the cornea, when fresh, cannot be made out even with the best magnifying powers. In its recent condition, only such tissue elements can be distinctly seen as refract light otherwise than do the parts surrounding them. Thus, if fibres or cells are imbedded in connective substances or an interstitial fluid, the optical behaviour of which does not differ from that of the tissue elements, then they cannot be seen even with the best magnifying powers; artificial means must be resorted to.

These are either mechanical for the purpose of tearing from each other the tissue elements, or they are chemical, the use of which consists in such cases in either dissolving the cementing substances, or changing them differently from the elements themselves. The best artificial preparations, however, cannot replace

that which observation in the fresh state yields with a power magnifying 1000 to 1500 times. Those contours which can be recognized even during the life of the tissues show beside their sharpness a peculiar softness, which makes observation agreeable. The natural cavities and fissures are exceedingly well marked from their surrounding parts in consequence of the different refracting power of their contents. Lastly, contours are visible during life, which disappear with the death of the tissues. Though by special reagents these can again be made visible, they acquire their full value only by our knowing that they have been visible even without reagents.

According to what has been said of the present state of instruments, it may be expedient to conduct comprehensive topographical studies with weaker lenses, the study of tissues in preparations modified by treatment with medium lenses, and to employ strong magnifying power in such cases only for controlling the *depth-distances* (?), and lastly to carry on the investigation of fresh tissue exclusively with the best existing instruments.*

The simplest, but at the same time the most successful and most elegant, way of examining under a compound microscope is by laying the object upon the middle of the highly polished glass slide, covering it with a thin quadrangular plate of glass, likewise perfectly clean. The glass plate, also called the glass cover, ought to lie with its surfaces parallel to the glass slide, which can only be effected when the stratum to be examined spreads out regularly to a greater extent than it. Irregularly bordered thick lumps interfere with the examination by forcing the glass cover into an oblique position. If the tissue to be examined is distributed through a fluid, a small drop of it should be placed upon the glass slide; the top of the drop is then to be gently touched with the glass cover, and this then allowed to descend slowly upon it. The inclusion of air-bubbles is thus avoided. If the investigation is to be carried on for a longer time, or if we are anxious that the medium in which the tissues lie shall not become more concentrated at the margins, then it is better to apply with a brush a layer of oil round the margins of the glass cover; the preparation will, in this way, be protected from evaporation. If after the application of the glass cover, a part of the fluid to be investigated should flow beyond its margins (the glass cover acquiring thereby an unsteady and easily movable position), then its margins must first be dried with filter-paper, after which the layer of oil may be put on. In this way we obtain the simplest moist chamber.

* To the binocular stereoscopic microscopes, I cannot attach much value for the service they have rendered hitherto. Up to the present they have been used with low magnifying powers only. But with the simple microscope the appearance of relief may be obtained exceedingly well if, during the observation, the head is maintained in a slightly oscillating motion.

Recklinghausen has introduced the use of moist chambers. The fundamental idea for such an arrangement was that the object be introduced into a space, saturated with aqueous vapour, and this appeared especially necessary when it became desirable to examine without the glass cover. In such a case the object is partially surrounded by an atmosphere, to which it gives off aqueous vapour should the atmosphere not be saturated with such vapour already.

If we, on the other hand, take into consideration that the deposition of aqueous vapours from a saturated atmosphere upon such an object is dependent on the temperature of the latter, it will be easily understood how difficult it is to arrange everything in such a way that water is neither taken up nor given off. At any rate the errors will diminish with the dimensions of the atmosphere which surrounds the object. The atmosphere should therefore be made as small as possible, and should as much as possible be reduced to nil, therefore as long as possible one should work with a glass cover the margins of which are oiled. The pressure which it exerts upon the object is inconsiderable, while it can easily be avoided. It is only necessary to make a wall of oil, to apply the drop within this wall, and then to cover it, in order to be protected against the pressure exerted by the glass cover. But as regards the experiment, it may from other causes become necessary to surround the preparation with an atmosphere. The influence of various gases, for example, may have to be passed over it in the course of the experiment. In such a case an actual chamber must be established, and this must be kept as small as possible as long as no other arrangements are made to regulate the movements of the aqueous vapour. For this purpose I would propose to apply upon the ordinary slide a ring of putty of the required thickness, to place the object, as is now practised everywhere, upon the glass cover, to bring this down upon the wall of the putty with the object turned downwards, and to press it down gently by running the handle of the scalpel over it. A drop of water upon the bottom of the slide will suffice to saturate the space with aqueous vapour, and to preserve the object from drying. But here also great caution should be used, for it will be found that the dry and polished cover-plate is tarnished as soon as it is put upon the wall of putty. The drop of fluid must therefore have a small surface, in order not to evaporate too much; it must, on the other hand, not be too small, lest the object dry too soon.

Such a chamber may easily be transformed into a so-called gas chamber. Into either side of the soft wall of putty, corresponding to the middle line of the glass slide, a small glass tube may be introduced, to each of which is attached a correspondingly diminutive caoutchouc tube. When no gas is to be sent through them, they are closed by small pinch-cocks. When the gas is to be passed

through, the necessary communication is to be established with the caoutchouc tubes, and the pinch-cocks opened. Those, however, who work more frequently with gases will not be satisfied with a provisional chamber so easily destroyed. Then it is better permanently and firmly to cement the conducting glass tubes into grooves in the glass slide. The space, which is to be filled with gas, can then be again enclosed by a wall of putty.

A slide, which is used for such examinations with gas, must be held down upon the stage of the microscope, because the conducting gas tube drags on it, in consequence of which the object may be moved out of its position during the examination. The gases should be evolved from wash-bottles which are fixed upon the table, so that definite relations may subsist between the wash-bottles and the microscope, whatever may be done with the gas apparatus placed at a distance from the table. That I may be quite independent in my microscopic labours of the aid of assistance, and in order that table and hands may not be taken up with other than purely microscopic objects, I arrange my gas apparatus below the table in such a way that by movements of the feet I am enabled to set the one or the other agoing. If carbonic acid, for example, is to be made use of, I place the apparatus below my table in such a way that a bottle holding the hydrochloric acid can be raised from the floor by means of a foot-board and a cord running over pullies, and the acid thus caused to run into the evolution-bottle by a caoutchouc tube passing between necks in the lower parts of the bottles. From the evolution-bottle a caoutchouc tube leads then into the fixed wash-bottle on the table, and from this proceeds the communication with the microscope. The conduction of carbonic acid to a microscope requires, however, the possibility of its exchange for atmospheric air. I insert, therefore, a T-shaped tube between the wash-bottle and the glass slide. The direct arm of this tube lies in the line of communication between the wash-bottle and the glass slide, with the cross-piece turned towards the observer. To this is now attached a long caoutchouc tube, the extremity of which the observer holds between his teeth. Between the T-shaped tube and the wash-bottle a clamp is applied. If I now open the clamp, lift the bottle containing the acid by treading down upon the foot-board, send in this way carbonic acid into the wash-bottle, compress at the same time the caoutchouc tube between the teeth, the gas must pass over the slide. But if I close the clamp, and suck at the end of the tube in my mouth, I draw atmospheric air into the chamber from its opposite side. Thus it is in one's power to introduce a succession of atmospheric air and carbonic acid whilst observation is being carried on, and the hands are left free for necessary manipulations. A second, so-called Deville's apparatus, under my table arranged in the same manner as the first, is suitable for the evolu-

tion of hydrogen. This gas I use as an indifferent reagent, in order that it may carry with it in its passage through a wash-bottle vapours derived from its contents—for example, ammonia, chloroform, &c. The same object is obtained by a pair of bellows worked by foot and furnished with a delivery tube leading into the wash-bottles. When hydrogen is wanted as such, the gas chamber described is not sufficient. Kühne, to whom we owe the first experiments with gas chambers, proposes for this purpose a mercury joint. Following this principle, I take a slide formed of hard caoutchouc, the middle of which is perforated, and to one surface of which a glass plate is cemented, or, what is the same, I cement to a glass plate a ring of hard caoutchouc. The surface of the ring opposed to the plate is now to be provided with a groove surrounding the space, into which groove mercury is to be poured.

The glass cover must then by means of hard cement be converted into a vessel resembling the lid of a box. To the inner surface of this vessel the object is then applied, and its side walls dropped into the groove so as to dip into the mercury. Then, if the glass cover is held down by clamps, the gas chamber is tightly closed, and, as a matter of course, gases may be introduced by suitably applied conducting tubes.

There are certain difficulties attending the examination of objects in gas chambers. We will take the simplest case. A drop of blood is applied to the under-surface of the glass cover; the latter is placed upon the chamber, and firmly cemented to it. The first stream of gas which passes through is quite sufficient to dry the blood at its edges. This evil can scarcely be remedied. It is therefore necessary to accustom oneself, in the case of gas chambers, to very quick experiments, or else to add to the preparation so much indifferent fluid as that the preparation itself may, without being injured, saturate the little chamber with water-vapour. We work then no longer under the simplest conditions, and the conclusions of which the experiment admits must be referred to the conditions under which we set out.

Still more difficult is the employment of the moist chamber, when the object under the microscope has to be heated.

It was Rallet who introduced the change of temperature into microscopic experiments. Max Schultze has improved this experiment, since he constructed a heating-stage which, adapted to the ordinary stage of the microsoope, heats it throughout, thereby giving any desirable temperature to the object. It has been tried to elevate the temperature of the object in different ways. In Max Schultze's stage, direct conduction by metal plates has been applied as the principle of heating. Then an attempt was made to conduct warm fluids through the stage, and lastly even warm vapours were used in the same way. Before any of these devices, the plan of heating

the stage by converting constant currents into heat recommends itself to us. In microscopic experiments only very small quantities of heat are required, and it is not at all necessary for the stage to be heated throughout its whole extent, but only its centre, or what is still better, a glass plate inserted in a caoutchouc plate. Such small quantities of heat might be expected from the circulation of even weak currents. It is known that the heating of a wire which forms part of the circuit of a constant battery increases as the thickness of this wire diminishes—according to Riess, inversely as the square of its diameter. It is therefore only necessary to fix a correspondingly thin wire into the middle of a glass plate, put the two ends of the wire in communication with the electrodes of a constant battery, and close the current, and the glass plate gets heated. The cementing on of a wire is, however, inconvenient; we have an excellent substitute in tinfoil. Thus I cut the tinfoil in the form of a picture-frame, with two arms projecting from opposite sides, gum it to a slide, and connect the two ends of the tinfoil with the poles of the battery, and our object is attained.

A very convenient method of connecting it with the battery is the following:—Brass springs are added to Hartnack's microscopes, by means of which the preparation can be held in a desired position. These springs, which are inserted by brass pins into hobs in the stage, I provide with caoutchouc pins; thereby they are isolated from the microscope. Whilst retaining the object-bearer in its place, they can at the same time press upon the broad ends of the tinfoil. I need then only affix a conducting-wire on any part of the spring on each side, and the circuit is closed by the tinfoil. A second strip of tinfoil of the same width as that affixed to the slide wound round the bulb of a thermometer, and inserted in any part of the circuit and suitably protected, indicates the temperature which the centre of it must have, if all secondary conditions are the same in both cases. These secondary conditions, however, may be met by the judicious use of the thermometer, which is necessary in all cases, according to whatever method the heating is carried on. A quantity of fat, the melting-point of which is known, should be put upon the place where otherwise the object would be placed, to ascertain the height of the column of mercury at the moment when the fat begins to melt. The fat should moreover be employed in pieces of microscopic size, and be watched through the microscope. It is best to cut a disc out of the fat, to cover it *lege artis,* to view it with a given base, and to make use of it for this lens.

VI.—*On the Construction of Object-glasses for the Microscope.* By F. H. Wenham.

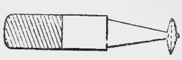
(Continued from page 347, No. VI.)

On the Production of Spherical Surfaces in Glass.

As the radii required in the construction of microscopic object-glasses are seldom very long, the templates for all sizes above $\frac{1}{5}$th of an inch in diameter are usually made of steel, such as thin saw, spring, or busk-steel, not softened, but turned hard, as obtained. A hole is punched through the middle of a square plate with a centre punch, the hole is then rounded out with a taper rimer. The piece of steel is next broken round as near as possible to the size of the circle required, by clamping it in the vice and driving off the surplus metal round the edge with a chisel held close to the jaws. This steel plate is driven on to a mandril so as to turn true without any wabble. The lathe is run at a slow speed, and the T-rest placed rather high near the top of the work, which is turned true with the common square graver held over-hand. The chamfered edge of the templates may form an angle of 90°. Every convex template should have its counterpart or concave; the steel plate to form this is clamped flat on to a face-chuck by a ring with two opposite screws tapped into the plate. The inner circle is turned out with a side tool, consisting of an old saw-file ground to a point on the three faces. The turning is continued till the disc or gauge just drops through; the inner edge is then chamfered from both sides.

Gauges below $\frac{1}{5}$th of an inch in diameter are made from steel wire turned to the annexed form (Fig. 1). The disc end is hardened by heating it with the lamp and blowpipe, and quenching it in oil, and the counter-gauges are most easily formed by a counter-sink rose-bit run in the lathe. The plate of steel is chamfered out alternately from opposite sides, by forcing it up on the socket of the back centre, till the disc will pass through; the hollow templates are, of course, cut in half before they can be used.

Fig. 1.



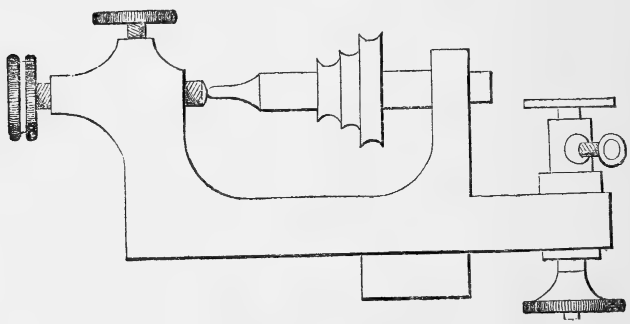
An instrument for measuring the diameter of the discs, &c., is indispensable. It consists of a pair of sliding steel jaws, with a vernier and nonius capable of being read off to thousandths of an inch, and is sold by the watch tool-makers.

The moulds for grinding minute lenses are always of brass; they are also used in pairs. The concave is turned out to the gauge, and the convex to the counter-gauge. For small radii the hard gauges are finally used for the last correction, as a turning, or

rather scraping tool, and finished by grinding the two moulds together with the finest emery.

There is some difference in practice between the grinding of lenses for long and short radii. In the former, as for telescopes, the glasses are fixed, or have but a very slow rotary movement, and the concave tool is worked over them, either several at a time in blocks, or else, if a shallow curve is required, only on one single disc: this is placed in the centre, and a number of smaller pieces of glass planted round the circumference to support the figure, the whole being ground as one. But in the lenses to which this paper particularly refers, the concave tool is invariably caused to revolve rapidly, and the convex lens worked into it. For the longest radii and lowest powers the ordinary foot-lathe is suitable, but this is not so well adapted for grinding and polishing very minute lenses. A bow lathe, such as used by watchmakers for heading their screws and other purposes, is far preferable. This tool is represented half size by the annexed cut (Fig. 2), and scarcely needs

Fig. 2.

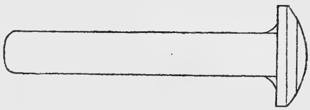


explanation; it has a hollow screwed mandril and T-rest, and is held in the vice by the tongue at the bottom. The pulley has three speeds, the smallest of which is three-eighths of an inch in diameter; it should also have a socket for carrying a fixed magnifier, under which the minutest lenses are turned. The best bow is an old fencing-foil ground down so as to be very thin and light. Catgut does not answer well for the string, as it soon gets frayed out over the small pulley. I have found the best packing-twine preferable. During work this is kept slightly moist, and rubbed with a piece of soap; in this way a length of it will outlast a day's work, especially if a little more twisted before it is attached to the wire hook at the top of the bow. A surplus stock of string may be wound about the guard, just above the handle, so that it can be drawn out as required.

The same rules for guarding the extreme edges of lenses should

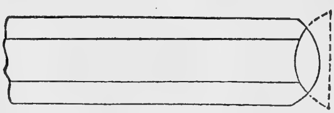
be observed, as described in prism-work, shown by the following examples. Fig. 3 represents a plano-convex lens which has been made and finished upon a flat disc of glass, to which it has been attached with hard Canada balsam. The two discs are cemented to the stick with black sealing-wax; the lens and supporting disc are rough ground on the zinc plate till they nearly fit the concave gauge, they are then ground in the brass mould till the lens measures very nearly the diameter required, leaving a small allowance for smoothing and polishing.

Fig. 3.



For double convex lenses, the disc of glass, cemented on a stick as usual, is first ground and polished on one side. A piece of glass tube of suitable size is selected for a handle, and the end of the bore ground out to a similar radius; the polished side of the unfinished lens is then cemented into this concavity, and the lens and tube ground and polished off together, as shown by Fig. 4, taking the same precautions as before to work the lens up to the exact diameter required. The dotted lines show the rough disc as cemented down. By this method all the marginal errors are taken up by the glass tube-holder, of which an assortment of various sizes will be required, from a minute bugle, up to half-an-inch or more in diameter. Before using the holders again for other lenses, the end must be ground out on each occasion, so as to increase the diameter of the cup. The lens, when taken out by being warmed, will have a knife-edge perfect to the extreme.

Fig. 4.

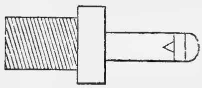


In minute lenses, some difficulty will be experienced in obtaining the measurements by means of gauge instruments, when near the right diameter. I therefore, for small sizes, always use the microscope with micrometer eye-piece, having previously taken the exact size from the diameter of the cell in which the lens is to go. This is very accurate and convenient. After the finished lens is taken out of the holder, if it should be found too large to enter the cell, it may be slightly cemented to the end of a wire, and twisted into a piece of the finest emery-paper, held in a hollow form, and the keen edge is taken off till it passes through.

The single fronts for the highest powers, from their form, do not admit of being ground in this way. A piece of brass or steel is screwed into the mandril, and the end turned of a size to enter the cell into which the lens is to go; the end is turned flat, or rather slightly hollow, and the centre taken out. A piece of crown-glass is cemented by its polished side to the flat end, with the best

orange shell-lac, and turned with the diamond point till it nearly enters the cell. The last finish may be given by fine emery-paper wrapped round a flat piece of hard wood. The extreme end of the glass is then turned off flat, till it equals the thickness of the intended lens, from the apex to the flat, as measured by the jaws of the gauge; the lens is next turned off by the diamond to the curve required, as shown in the cut (Fig. 5); and, finally, the chuck is removed, and the lens ground and polished in the mould as usual. In all cases of cementing lenses on to chucks in this way, care must be taken that they are well pressed down, so that the layer of cement may be of the same thinness all round, otherwise the lens will be tilted and out of centering from unequal thickness. When taken off, the lac may be cleaned off with alcohol.

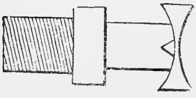
Fig. 5.



A similar mode of chucking is employed for a plano-concave lens. The polished flat side of the flint glass is cemented to the chuck, made just to enter the cell; but in order to appreciate the thickness in the centre, the circumference of the disc, after it is turned to fit the cell, is polished with a piece of hard wood and crocus. The concavity is then turned out a trifle deeper than the radius of the circular gauge, till a mere line of light only is observable by looking through the polished edges. The chuck is then removed from the mandril, and the lens thereon ground and finished on the convex tools.

For a double concave lens, such as is used for a triple back, the end of the chuck, instead of being flat, must be convex, to match the radius of the concave surface of the disc of glass that it is to receive, this having been previously ground out and polished independently in the usual way of cementing it on to a stick; but as the curves are shallow, it is best not to turn the disc down to the intended size at once, but leave it much larger than the cell or chuck, thus (Fig. 6); and after it is polished as before directed, the chuck is again screwed into the mandril, and the lens turned down so as to fit the cell; this is done in order to avoid the marginal errors which would arise from working a shallow curve of small diameter.

Fig. 6.



The same precautions have to be observed in smoothing lenses as directed for prism-work; the finest emery is used, and the requisite moisture applied as required by breathing on the lens, taking care that the accumulation of powder is removed from time to time from where the centre of the mould has been dug out, otherwise this may contain some coarser particles that may cause scratches.

As before remarked, the moulds are made in pairs; the convex

and concave are turned to their respective gauges, and then ground together. The diameter of the mould should always rather exceed that of the lens intended to be ground; and the centre, or "pip," is taken out; unless this is done, a prominence is left at this spot, which injures the work. During the smoothing, the two moulds should occasionally be worked together, as this greatly tends to ensure the accuracy of figure of the lens; and after this is completely smoothed, the moulds should be again matched, so as to leave them with a polished surface, for a reason to be hereafter explained.

Having got our lens perfectly smoothed and figured, the next operation is the polishing. It is almost impracticable to perform this in the hard mould, and therefore various substances are employed, of a less degree of hardness, in which the coarser particles of polishing-powder may become imbedded. For the larger sized lenses in microscope work, beeswax, hardened with some resin and finely-washed ochre, is very suitable; but for medium sizes this is too soft and yielding; a mixture of shell-lac and washed putty-powder is therefore employed, which is very enduring. These are melted together and stirred diligently; the shell-lac is added till the whole arrives at the consistence of thick paste; and as the lac is apt to burn, to prevent this, a lump of beeswax should be thrown into the mass. This does not actually mix with the other ingredients, but lessens the risk of spoiling the composition by overheating: when cool enough this may be rolled into sticks between two greased boards.

For the very smallest lenses, such as the fronts of a $\frac{1}{25}$th and $\frac{1}{50}$th, the last composition is still too soft and fragile to maintain a true figure. The polishing mould is therefore, for these, made in the end of a rod of pure tin, which is cut out into a nearly hemispherical cup by the appropriate steel gauge; the "pip" is removed with a needle-point.

The wax-polishing bed is turned out to the required radius, and finished by scraping with the steel gauge; but as the material is somewhat yielding, the lens soon plys to the mould and keeps its figure during the polishing.

The second composition is very hard and brittle, and does not yield at all, and as the body is composed of the hard oxide of tin, this would speedily injure the gauges if used as cutting tools. The method that I have adopted for forming the polishing moulds from this substance is as follows:—A lump of the material is fastened by heat into a ferrule, or hollow cup, running in the lathe; the end is then turned either convex or concave, and of a diameter suitable for the lens to be polished; the convex or concave mould, as required (which has been worked off at last near to a polish, as before explained), is then screwed on to a handle, and held in a flame till,

when touched with the moistened finger, it hisses smartly; a morsel of tallow is then put on the rough-turned composition to prevent adhesion, and the hot mould worked and rotated over it in every direction till cold; when removed, the polisher will have taken the exact form of the heated mould, and have acquired a fine polish. For either convex or concave lenses the "pip" is taken out as usual, and it is advisable to make a few concentric scratches in the polisher if of large diameter.

As the mixture of crocus and putty-powder, recommended for polishing, is apt to cling in these moulds if applied at once, I first use the putty-powder alone; this cleans the hard polish off the face, and the operation may then be continued with the mixture.

One great advantage of this composition, for a polishing mould, is the decided way in which it maintains a true figure; for, unlike any other of the kind, it undergoes a very slight degree of wear, so that the face is always kept clean; and any number of lenses of similar form and radius may be polished in the same tool without having to alter or mend the figure, and perfect accuracy is the result. This composition is now generally known, but Mr. James Smith is the original discoverer of it. For the last degree of polish, I sometimes rub a thin layer of pure soft beeswax in the mould, and smooth it down to form with the now finished lens; then a small quantity of the very finest-washed crocus is applied, and the lens worked therein for about one minute. The extra brilliancy of surface obtained this way is quite appreciable, and well worth the pains bestowed, as the operation is not continued long enough to run the risk of injuring the figure.

I have only now to give some directions for cementing the lenses together. The surfaces having been carefully cleaned, the two lenses are laid on a hot plate, a drop of Canada balsam is placed in the concave, the group of bubbles thrown up by the heat removed by a brass point; with this the convex lens (which is equally hot with the other) is lowered slantways into the balsam so as to avoid bubbles, and the two lenses are pressed together; they are now lifted off the plate with a pair of curved forceps held nearly horizontally, and shifted one-quarter round, and then dropped down again. This is repeated a number of times, and the two lenses being exactly of the same diameter, this operation must set them concentric as a matter of course. If the lens is a triple, the opposite surface of the concave must be cleaned and the balsam removed with strong alcohol (turpentine must not be used, as it percolates the balsam too easily, and is apt to cause bubbles to appear at the edges), and the same operation repeated as on the other side. When the lens is cleaned with alcohol, and examined edgeways with a magnifier, the three lenses will appear quite concentric, and should just pass into the cell without requiring any

force; and if the workmanship has been correct—*viz.* all the cells turned true from one chucking, and the *concaves* of equal thickness and concentric with their respective convex lenses, no errors of centering can occur. The usual way of correcting this is by tilting the lenses in the cells, in which they are cemented with Canada balsam; but at the best this is only to some extent substituting one error for another.

VII.—*Jottings from the Note-book of a Student of Heterogeny.*

By Metcalfe Johnson, M.R.C.S.

As the spokes of a wheel converge to the centre, so do the concurrent radii of evidence point to an axis of truth, either comparative or absolute.

The following remarks are simply a description of some experiments and observations made during the last two years in the intervals of leisure in a life of practical medical labour. The bearing of the facts upon the great questions of Speciology, Epidemiology, and Nature's scavenging, will be at once evident, and will (it is believed) be found to run in a similar direction to the facts recorded and opinions expressed by Hicks, Sachs, Itsigsohn, Fries, Lindsay, Frau Luders, Pasteur, Pouchet, Archer, Lund, and others.

The observations, for the most part, have been made under a magnifying power of 250 linear, while a few have required 700.

In November, 1867, some observations made under 700 linear upon the tubules of *Lyngbya muralis* showed every variety (increasing in size) of Monas lens (or what appeared identical with it), to what when outside the tube appeared to be Convallaria in an undeveloped state; green Gonidia, oval green bodies, and masses of chlorophyll inside the tubule.

The various bodies, with the exception of the chlorophyll masses, were in active motion; at the same time, I have frequently witnessed masses of chlorophyll slowly traversing the vacuole of the tube and, in some instances, the chlorophyll mass has given out a blastoderm which assumed a transparent globular form as of a vesicle, into which I have seen the small masses of chlorophyll empty themselves. In addition to this, bodies apparently identical with Monas lens have escaped from the chlorophyll blastoderm into the terminal vacuole of the tubule, and there rotated after the manner of monas, and in the course of time attached themselves to the extremity of the vacuole. This I have witnessed in my researches to find the bursting gemmules described by Dr. Hicks in

his monograph on the Gonidia of Mosses.* The cells escaping from the chlorophyll mass are devoid of colour, and escape by bursting of the blastoderm, and have at once independent rotating movement on their own axis.

On August 31st, 1866, some yeast, flour, sugar, and water, were placed in a bottle under a vessel containing ozonized air (made by phosphorus), and gave off 35·2 per cent. of carbonic acid; while the same quantity of yeast, &c., was placed under a jar of common air, and gave off 17·3 per cent. of carbonic acid.

By means of an air-sieve, I have collected distilled water trickled over a glass plate into a trough, and found varying quantities of Monas lens besides other air-contents.

Paramœcia subjected to the action of solution of potassic permanganate instantly cease to move, and assume a rust-brown colour, while the purple of the original solution is destroyed (manganic oxide ?).

Solutions of potassic permang. (one centimètre equal to ·01 of a grain of organic matter), when added to water from the air-sieve, show discolorization varying from ·01 to ·10 to the pint.

Rain-water shows a greater discolorization than distilled water.

Distilled water sprayed through the air of my room shows ·40 grain organic matter to the pint.

The following are the results of an experiment, March 5, 1868:—

One pound cow-dung from centre of a recent deposit (kept in stoppered bottle six weeks), mixed with 20 oz. distilled water, and disposed of as follows:—

a. 2 oz. in clean bottle, with only a bubble of air, corked and sealed.
b. 1 oz. in 2-oz. bottle, corked and sealed.
c. 2 oz. in open glass beaker, with carbolic acid, placed in rather dark room.
d. 2 oz. placed in a saucer, exposed to air in a rather dark passage.
e. 2 oz. placed in a round evaporating dish outside the window of my room.
f. 2 oz. in square dish outside the window.
g. 9 oz. in tall glass jar outside the window.
e, f, g. Exposed to air and *light* and *rain*, examination showed the following results:—

a. *March 5th.*—No moving germs.
April 2nd.— „ „ Bottle accidentally broken.
b. *March 5th.*—No moving germ.
„ *20th.*—A few monads; Mucedo on cork.
„ *22nd.*—Monads very numerous, movement saltatory; no Mucedo granules.
„ *26th.*—Monads and Vibrions very abundant.
April 2nd.—Monads and Vibrions, all transparent, no green colour.

* 'Trans. Lin. Soc.,' vol. xxiii., Tab. 58.

April 17*th*.—Paramœcium.
„ 26*th*.—A few monads; no Paramœcium.
June 24*th*.—(Bottle lightly corked) Oscillatoriæ (exposed to light).

c. March 5*th*, 12*th*, 20*th*, *April* 2*nd*, 26*th*.—No moving germs on any inspections.

d. March 5*th* and 7*th*.—No moving germ.
„ 10*th*.—Several monads; one Paramœcium.
„ 17*th*.—Numerous full-sized Paramœcia; monads of every grade and size.
„ 20*th*.—Monads large; Paramœcia.
„ 22*nd*.—Shape of Paramœcia (like Euglena).
„ 26*th*.—Paramœcia, large and abundant; CILIA.

e. March 5*th*.—No moving germs.
„ 12*th*.—A few monads.
„ 17*th*.—Monads numerous, very small.
„ 20*th*.—Many small monads.
April 2*nd*.—On surface, green Gonidia (Euglena ?), very active; monads, few greenish; on side, green filaments; transparent slowly-amœboid bodies; one very delicate Amœba; green Gonidia; one gleocapsoid cell.
April 4*th*.—Many large green Gonidia nucleated.
„ 7*th*.—Dried up.

f. March 5*th*.—No moving germs.
April 6*th*.—Green Gonidia, large nucleated.
„ 7*th*.—Green Gonidia.

g. March 5*th*.—No moving germs.
„ 12*th*.—Monads.
„ 17*th*.—Monads very numerous.
„ 26*th*.— „ „
April 13*th*.—Two circular plants of Mucedo from a jar of paste put into the liquid.
„ 15*th*.—Surface one mass of Vibrions; no Mucedo.
„ 17*th*.—Surface a moving mass of Vibrions, side (exposed to light), green Gonidia (?) very numerous, round, all active.
„ 21*st*.—Surface, Vibrions, no gonidia; side, green Gonidia (?) rotating on their own axes.
„ 22*nd*.—Side, thousands of green Gonidia (?).
„ 26*th*.—Numerous Euglena, equal in size and appearance to those grown in fields.

March 6*th*.—4 oz. distilled water placed in a glass beaker outside window.
„ 12*th*.—Several Gonidia and starch granules ?
„ 20*th*.—A few monads.
„ 22*nd*.—A group of green Gonidia.

April 2*nd*.—A few monads, some black sediment, soot flakes, silex and starch granules, and one green Gonidium.

The following are the details of an experiment with infusion of hay (cold one hour), which showed under microscope no moving life, prepared May 25, 1868.

A.	1 oz.	infusion	of hay, in	bottle, no air, corked and sealed.
B.	1 oz.	„	„	$1\frac{1}{2}$-oz. bottle, $\frac{1}{2}$ oz. air „
C.	3 oz.	„	„	3-oz. bottle, no cork, in dark cupboard.
D.	10 oz.	„	„	glass beaker, outside window.
E.	14 oz.	„	„	long glass jar.
G.	2 oz.	„	„	saucer in dark passage.

RESULTS.

A. *May* 25*th.*—No moving life.
Aug. 20*th.*—No moving life.

B. *May* 25*th.*—No moving life.
June 3*rd.*—Mucedo on cork, and few rotating monads in liquid; no moving life.

C. *May* 25*th.*—No moving life.
„ 27*th.*—Filaments of Mucedo with fructules; elongated cells; no movement.
„ 30*th.*—Plant of Mucedo closing mouth of bottle; several Paramœcia.
June 1*st.*—A new scum; innumerable Paramœcia.
„ 2*nd.*—Surface film one mass of moving Paramœcia.
„ 6*th.*—Paramœcia and monads.
„ 22*nd.*—A green slime on surface.

D. *May* 25*th.*—No moving life.
„ 27*th.*—Filaments, cells, and discs of Mucedo; one or two cells slightly moving.
„ 29*th.*—Monads very active at bottom.
„ 30*th.*— „ numerous.
June 1*st.*—Surface, a few monads; bottom, a mass of monads; one or two filaments.
„ 2*nd.*—Bottom, cells and filaments. A bottle containing Conferva rivularia has similar filaments of Mucedo on surface.
„ 3*rd.*—Monads very active, smaller than in **E.**
„ 6*th.*— „ and filaments, very small.

E. *May* 25*th.*—No moving life.
„ 27*th.*— „ „
„ 29*th.*—Innumerable monads.
June 1*st.*—Side to light, a mass of monads; surface, film of monads; one Paramœcium.
„ 2*nd.*—Side, monads of every size and shape.
„ 3*rd.*—Surface, filaments, with very active Paramœcia.

G. *May* 25*th.*—No moving life.
„ 27*th.*—Mucedo round and elongated; no filaments; monads very distinct and active.

May 29*th.*—A few monads.
„ 30*th.*—A large number of Paramœcia.
„ 31*st.*—Dried up.

The following extracts from notes taken at the time of observation.

April 15*th,* 1868.—In water containing Lyngbya I witnessed the vacuole changing its position in Euglena cells.

April 28*th.*—Observed a green zoospore (Euglena), in a fluid containing Lyngbya, change its shape, and the size and position of its vacuole in the slow way of an Amœba; at times becoming almost free from colour. Motion, slowly revolving on its axis; no cilia.

Another green zoospore, with amœboid change.

April 15*th.*—Numerous small zoospores in Lyngbya water, each having a delicate green bag of chlorophyll rolling about in the cavity.

Witnessed two or three of the spots in Paramœcium coalesce into one, and instantaneously disappear, as if by contraction of the cell-wall; this I have frequently verified.

May 6*th.*—Found a Paramœcium in Lyngbya water (April 27th), containing several green Gonidia or chlorophyll particles.

May 11*th.*—Saw a Paramœcium burst in water enough to float away in a granular stream. This I have frequently observed, but the bursting always seemed due to the evaporation of the water used to float the object.

May 20*th.*—Specimens of Paramœcium observed in Lyngbya water (put up May 11th).

May 20*th.*—I observed these changes: a globular and elongated Paramœcium first attached, then separate, and finally the envelope of the globular body seemed to burst, and the contents became absorbed in the elongated object, and thus the two became one Paramœcium.

June 12*th.*—Watched a small transparent body (Euglena) change form from oval pyriform to globular.

Aug. 20*th.*—In Lyngbya water (May 11th) saw numerous small bodies (Euglena), all transparent.

May 23*rd.*—Witnessed two Paramœcia struggling together for several minutes.

April 17*th.*—Saw two transparent Paramœcia coalesce to form one.

April 21*st.*—Among other forms of Paramœcium found, also a very large number of Convallaria.

May 7*th.*—Saw Paramœcium from Lyngbya liquid (April 27th) change form; also another.

May 4*th.*—Found a ring of Euglena formed around the upper edge of a bottle, into which Lyngbya was put April 27th.

May 6*th.*—Witnessed very slow changes in Euglena.

Saw Euglena of all shades, from green to colourless, in Lyngbya water (put up one month).

May 10*th.*—Found Euglena with red spot in Lyngbya water (April 27th).

May 11*th.*—Saw specimens of Euglena resembling large cells of Oscillatoria.

June 12th.—Watched an Amœba from water containing Conferva, and saw changes. Also several transparent globules, transformed to Amœba.

April 28th.—Again witnessed the monads, freely moving in the terminal vacuole of Lyngbya.

May 20th.—In water containing Euglena (put up May 11th) found Oscillatoria, Paramœcia, Euglena, Amœba, Vibrions, green Gonidia (Euglena?), and diatoms.

Aug. 20th.—In a bottle containing Oscillatoria in water, found a bright pink frond resembling Palmella cruenta, *no purple cells.* Green Oscillatoria in all stages.

April 21st.—Found (in a hothouse) a plant of Palmella cruenta passing to green; red cells in red frond, but absent in green part.

April 27th.—Another examination of a green part of a frond of Palmella cruenta from a hothouse; no red cells, all green.

May 11th.—On the green edge of a moist frond of Palmella cruenta are very fine filaments of Oscillatoria.

The red cells gradually enlarging and assuming a green tinge.

May 11th.—On the surface of a liquid containing Lyngbya (May 9th) is a shining pellicle of Oscillatoria.

May 10th.—In a green rim on the surface of Lyngbya water (which on May 4th consisted of Euglena), are now numerous filaments of Oscillatoria.

April 21st.—Examined Oscillatoria, in which the vacuole seems increasing in size, and the chlorophyll masses becoming more distinct.

May 6th.—Put a solution of Antimonii potass tartarate into two bottles, one with only a globule of air, the other half-full of air.

May 18th.—Liq. ant. pot. tart. in bottle half-full of air, contains round cells, like monads (still) and Mucedo.

Dec. 8th.—Opened the bottle with only a globule of air, no Mucedo, amorphous film at bottom.

Dec. 8th.—Examined Glucosuria put up Nov. 13, 1868.

In bottle containing half air, found very large Mucedo.

In bottle with only a globule of air, no traces of Mucedo.

VIII.—*A Supposed Mammalian Tooth from the Coal-measures.* By T. P. Barkas, F.G.S.

I have recently, through the kindness of Mr. John Brown, Shieldfield, Newcastle-on-Tyne, been favoured with the examination of a slide which he has prepared containing a tooth and a portion of a jaw from the fossil remains of the Northumberland Coal-measures. There is at present in Newcastle and its neighbourhood great interest in the fossils of the Coal period, and several gentlemen have been engaged for a considerable time in preparing and mounting Coal-measure fossils for examination by the microscope. Thousands of sections have been made; and, besides those I have personally

prepared, I have examined a considerable proportion of those of my co-workers, but up to the present time neither they nor myself, so far as I have been able to ascertain, have seen a jaw with teeth resembling that I propose to describe to your readers.

The portion of a jaw about to be described is the more interesting because I have obtained from the shale which rests upon the Low Main coal-seam in Northumberland a mandible which, so far as it is exhibited in the matrix, has the appearance of being mammalian; and although I have obtained many hundreds of jaws and palate teeth, none of the specimens in my possession resemble it. I am therefore not willing to rub it down for microscopic examination until I have been fortunate enough to obtain another specimen, and am glad to have obtained the fossil to be described, because, unlike all fish and reptile teeth I have found and mounted, it possesses a long root or process by which it is inserted in the dentigerous bone. The teeth of fishes are anchylosed to the aveolar borders of the jaws; the teeth of reptiles are introduced thimble-like in series in the jaws; this specimen departs from both modes of attachment, and to that extent at least has one of the leading characteristics of a mammal tooth. As I do not pretend to the possession of an extensive knowledge of comparative anatomy or comparative odontology, I take the liberty of asking through your pages the opinions of your subscribers who have made comparative anatomy a speciality.

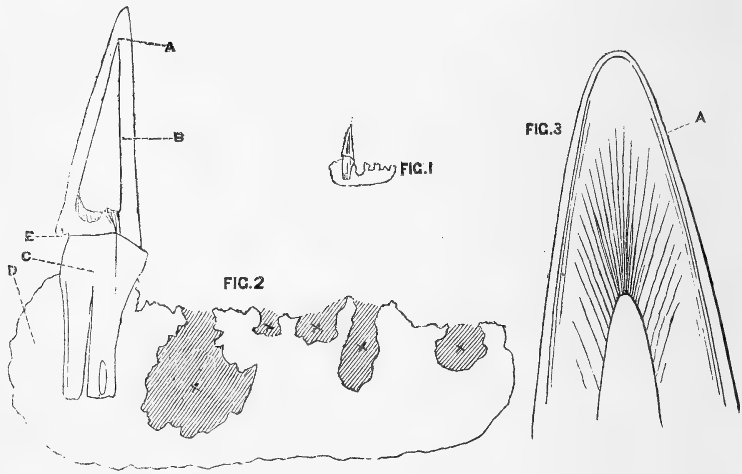
The question is the more interesting, because if this be a mammal tooth it is the first that has been discovered in strata so low as the Carboniferous, and that has been submitted to microscopic examination.

The length of the tooth is $\frac{5}{24}$ths of an inch; it is inserted for two-thirds of its length in the jaw.

Fig. 1 represents the specimen, natural size.

Fig. 2 illustrates the same fragment magnified ten diameters. The wedge-shaped cavity in the centre of the tooth is the pulp cavity; it is rounded at the base: the walls of the tooth consist of dense dentine, and are covered with a very thin coating of enamel. The roots are two in number, and appear to be divided by a space for the insertion of the nerves and arteries which supplied the tooth. The spaces in the jaw marked × are filled by the black substance of the matrix in which the specimen was found, and are probably cavities that have previously been occupied by teeth. Fig. 3 *a* represents the apex of the tooth magnified 250 diameters; the thin outer coating is the enamel, the dark inner space is the apex of the pulp cavity, the lines radiating from the dark space are the dentinal tubules which do not extend to the covering enamel. Fig. 4 *b* illustrates the right side of the tooth, half way between the aveolar margin of the jaw and the apex of the tooth; it is magnified 250

diameters, and exhibits the dentigerous tubules extending from the pulp cavity to the enamel, but not entering it; the tubules anastomose, and occasionally divide dichotomously; they are bolder in this portion of the tooth than at the apex.



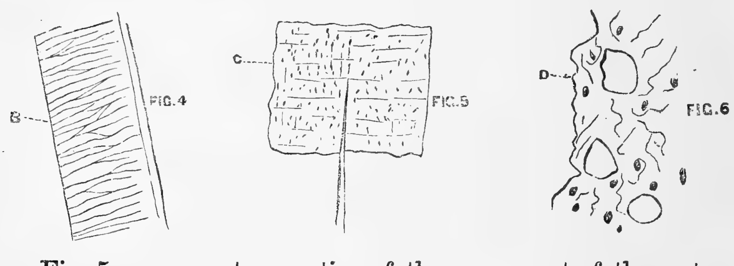


Fig. 5 *c* represents a portion of the upper part of the roots of the tooth near the point of junction of the two fangs, and is characterized by minute pittings, and irregular, broad, but faint transverse lines; it is also magnified 250 diameters.

Fig. 6 *d* is that portion of the jaw near the point of symphysis, and between the roots of the tooth and the anterior extremity of the jaw; it is a very open structure, not much unlike the substance of the oral armature of some of the Ctenodi; and covering the entire surface of the fragment of the jaw there are numerous lacunæ or radiating bone-cells. Any information which will lead to the identification of this apparently unique Coal-measure fossil will be esteemed a favour.

IX.—*On Holtenia, a Genus of Vitreous Sponges.* By Wyville Thomson, LL.D., F.R.S., Professor of Natural Sciences in Queen's College, Belfast.

During the deep-sea dredging cruise of H.M.S. 'Lightning' in the autumn of the year 1868, the dredge brought up, on the 6th of September, from a depth of 530 fathoms, in lat. 59° 36′ N. and long. 7° 20′ W., about 20 miles beyond the 100-fathom line of the Coast Survey of Scotland, fine, grey, oozy mud, with forty or fifty entire examples of several species of siliceous sponges. The minimum temperature indicated by several registering thermometers, was 47°·3 Fahr., the surface temperature for the several localities being 52°·5 Fahr.

The mud brought up consisted chiefly of minute amorphous particles of carbonate of lime, with a considerable proportion of living *Globigerinæ* and other Foraminifera, and of the "coccoliths" and "coccospheres," so characteristic of the chalk-mud of the warmer area of the Atlantic. The sponges belong to four genera; one of them was the genus *Hyalonema*, previously represented by the singular glass-rope sponges of Japan and the coast of Portugal, and the other three genera were new to science. One of these latter is the subject of the present paper.

Associated with the sponges were representatives, usually of a small size, of the Mollusca, the Crustacea and Annelides, the Echinodermata, and the Cœlenterata, with numerous large and remarkable Rhizopods. Many of the higher invertebrates were brightly coloured, and had eyes.

Four nearly perfect specimens of the sponge described in the memoir laid before the Royal Society were procured.

Holtenia, n. g.* H. Carpenteri, n. sp.

The body of this sponge is nearly globular or oval. Normal and apparently full-grown species are from 9″ to 1′ 1″ in length, and from 7″ to 9″ wide. The outer wall consists of an open, somewhat irregular, but very elegant network, whose skeleton is made up of large separate siliceous spicules. These spicules are found on the hexradiate stellate type, but usually only five rays are developed, the sixth ray being separated by a tubercle. To form this framework of the external wall, the four secondary branches of the spicule spread on one plane, the surface of the sponge, while the fifth or azygous branch dips down into the sponge-substance.

* The genus is named in compliment to Mr. Holten, Governor of the Faroe Islands, and the species is dedicated to Dr. W. B. Carpenter, V.P.R.S., with whom the author was associated in the conduct of the scientific expedition.

This arrangement of the spicules gives the outer surface of the sponge a distinctly stellate appearance, the centres of the stems being the point of radiation of the secondary branches of the spicules. These quinque-radiate spicules measure about 1″·5 from point to point of the cross-like secondary branches, and the length of the azygous arm is from 7‴·5 to 1″.

Smaller stars, formed by the radiation of smaller spicules of the same class, occupy the spaces between the rays of the larger stars.

The rays of each star bend irregularly, and meet the rays of the spicules forming the neighbouring stars. The rays of the different spicules thus run along for some distance parallel to one another, and are held together by a layer of elastic sarcode, which invests all the spicules and all their branches. Between the rays of the spicules, over the whole surface, the sarcode forms an ultimate and very delicate network, its meshes defining and surrounding minute inhallant pores.

At the top of the sponge there is a larger osculum, about 3″ in diameter, which terminates a cylindrical cavity which passes down vertically into the substance of the sponge to a depth of 5″ 5‴. The walls of this oscular cavity are formed upon the same plan as the external wall of the sponge, and the stars, which are even more conspicuous than those of the outer wall, are due to the same arrangement of spicules of the same form. The ultimate sarcode network is absent between the rays of the stars of the oscular surface.

The sponge-substance, which is about 2″ in thickness between the oscular and outer walls, is formed of a loose vacuolated arrangement of bands and rods of greyish consistent sarcode, containing minute disseminated granules, and groups of granules of horny matter, and endoplasts.

Towards the outer wall of the sponge the sarcode trabeculæ are arranged symmetrically, and at length they resolve themselves into distinct columns, which abut against and support the centres of the stars, leaving wide open anastomosing channels between them. The sarcode of the outer wall, and that of the wall of the oscular cavity, is loaded with minute spicules of two principal forms, quinque-radiate spicules with one ray prolonged and feathered, and minute amphidisci.

Over the lower third of the body of the sponge, fascicles of enormously long delicate siliceous spicules pass out from the sarcode columns of the sponge-body in which they originate, through the outer wall, to be diffused to a distance of not less than half-a-mètre in the mud in which the sponge lives buried; and round the osculum and over the upper third of the sponge, sheaves of shorter, more rigid spicules project, forming a kind of fringe.

I refer all the sponges which were found inhabiting the chalk-

mud to the order Porifera Vitrea, which I have defined in the 'Annals and Magazine of Natural History' for February, 1860. This order is mainly characterized by the great variety and complexity of form of the spicules, which may apparently, with scarcely an exception, be referred to the hexradiate stellate type, a form of spicule which does not appear to occur in any other order of sponges. The genus *Holtenia* is nearly allied to *Hyalonema*, and seems to resemble it in its mode of occurrence. Both genera live imbedded in the soft upper layer of the chalk-mud in which they are supported,—*Holtenia* by a delicate range of siliceous fibres, which spread round it in all directions, increasing its surface without materially increasing its weight; *Hyalonema* by a more consistent coil of spicules, which penetrates the mud vertically and anchors itself in a firmer layer.

It appears to me and to Dr. Carpenter, who have had our attention specially directed to this point as bearing upon the continuity and identity of some portions of the present calcareous deposits of the Atlantic with the cretaceous formation, that the vitreous sponges are more nearly allied to the *Ventriculites* of the chalk than to any recent order of Porifera. We are inclined to ascribe the absence of silica in many ventriculites, and the absence of disseminated silica in the chalk generally, to some process, probably dialytic, subsequent to the deposit of the chalk, by which the silica has been removed and aggregated in amorphous masses, the chalk flints.

The vitreous sponges along with the living Rhizopods and other Protozoa which enter largely into the composition of the upper layer of the chalk-mud, appear to be nourished by the absorption through the external surface of their bodies of the assimilable organic matter which exists in appreciable quantity in all sea-water, and which is derived from the life and death of marine animals and plants, and, in large quantity, from the water of tropical rivers. One principal function of this vast sheet of the lowest type of animal life, which probably extends over the whole of the warmer regions of the sea, may probably be to diminish the loss of organic matter by gradual decomposition, and to aid in maintaining in the ocean the "balance of organic nature."—*Abstract of a paper read before the Royal Society at its last meeting, June 23rd.*

NEW BOOKS, WITH SHORT NOTICES.

Entozoa: being a Supplement to the Introduction to the Study of Helminthology. By T. Spencer Cobbold, M.D., F.R.S. London: Groombridge, 1869.—Those of our readers who already possess Dr. Cobbold's larger treatise will be glad to see this supplement to so excellent a treatise on Entozoa. In some respects it brings down the original work to the present date, but in others it may be regarded as an independent work containing some valuable special chapters on questions connected with parasites. The section devoted to the history of the discovery of Trichina is very interesting. In it the author collates the evidence bearing on the point under discussion, and we think shows very satisfactorily that Mr. Paget must be regarded as the original discoverer of this entozoon. His concluding remarks are very significant, and allude indirectly to the tendency on the part of certain very distinguished biologists to slur over the work of their fellow-countrymen. They refer the reader in search of fuller information to the original letters on the subject, the sources of which are stated in the copious bibliography which the author appends to the volume, and they terminate in the following pregnant sentence, "There are persons on this side the Channel who systematically ignore the labours of their own countrymen." The second chapter is also of interest, as it records a number of experiments (twenty-nine) made on birds and mammals with the muscles of a Trichinised subject. These experiments bear out those made by Pagenstecher and others, in proving that the Trichinæ do not find a favourable nidus for their development in the intestines of birds, or at least do not penetrate the blood-vessels of the alimentary canal in these animals. A good many of the trials on mammals failed in giving absolute results, but some of them were so distinctly successful that they leave no doubt as to the cause of the Entozoa. The chapter of the work which will most interest the microscopist is that which refers to the peculiar bodies which were found in the flesh of animals which died of the rinderpest. Some histologists regarded these as being in some way or other connected with this disease, but Dr. Cobbold gives numerous observations to show that they are as often present in healthy as in diseased animals, and he cites various experiments made upon himself to show that they are perfectly harmless. He regards these bodies as Psorospermiæ, and gives the following account of their microscopic characters:—"The bodies are enclosed in a well-defined transparent envelope, and even under low magnifying powers their contents exhibit more or less distinct indication of segmentation. In some specimens the segments display themselves as a distinct cell-formation, the contents of each individual cell being uniformly granular. Even under the $\frac{1}{4}$-inch objective the contained granules are clearly

visible, and on rupturing the sac their peculiar characteristics are at once manifest. Each granule or corpuscle represents a pseudo-navicel, all of them displaying a tolerably uniform size, which I calculated to average $\frac{1}{2000}$ of an inch in diameter. Some of the corpuscles were round, others oval, several bluntly pointed at one end, many curved and fusiform, not a few being almost reniform; under the $\frac{1}{4}$-inch objective highly-refracting points or nucleoli were fairly visible in their anterior, but on employing the $\frac{1}{12}$th, I made out nothing more respecting the contents of the corpuscles."

The other chapters will be found full of important matter, and the list of authorities, bibliography, and index, show that details have been carefully attended to in preparing the work for the press. The author's remarks on "Organic Individuality," which he considers from an entozoologic point of view, are suggestive; but we think the system of division is pushed a little too far. We question very much the advisability of employing so many distinct technical terms to designate the numerous stages in the life-history of certain Entozoa. Helminthologists will find Dr. Cobbold's book a very complete supplement to his former investigations.

PROGRESS OF MICROSCOPICAL SCIENCE.

The Nervous and Vascular Systems of Limulus.—M. Alph. Milne Edwards has been investigating into the anatomy of *Limulus*, and he has discovered some very remarkable facts in regard to the structure of this singular crustacean. In a paper which he communicated to the *Société Philomathique de Paris* on the 26th of June, he stated that the researches of Van der Hœven and Gegenbaur, while excellent in their way, left nevertheless a great deal to be done still. His own researches had been made upon the animals in the great Aquarium at Havre, and had been directed especially to the circulatory apparatus, which he says is most remarkable. He has found that a portion of the blood on leaving the heart passes directly through a vessel with resisting walls, and which includes nearly the whole nervous centres, and even some of the nerves, especially those of the eyes and foot-jaws, in such a way that the ultimate nerve-fibres, which are very loosely connected, are completely bathed in blood. In point of fact, instead of having the nerves accompanied by arteries, the arteries actually enclose the nerves. He also notes the presence of very numerous anastomoses between all parts of the arterial system. Finally, he states that the mode of origin of the nerves shows that the small anterior foot-jaws of these animals are the analogues of the antennæ of insects and crustacea, and the chelicers of Arachnida. From these facts and others, he is disposed to rank *Limulus* among the spiders. (!)

Microspectroscopic Characters of Opals.—In the 'Proceedings of the Royal Society' for June is published Mr. Crookes' interesting

paper on this subject, accompanied by numerous woodcuts. The following are descriptions of some of the more remarkable spectra given by a number of choice opals:—No. 1 gives a single black band in the red. When properly in focus this has a spiral structure. Examined with both eyes it appears in decided relief, and the arrangement of light and shade is such as to produce a striking resemblance to a twisted column. No. 2 gives an irregular line in the orange. Viewed binocularly, this exhibits the spiral structure in a marked manner, the different depths and distances standing well out; upon turning the milled head of the stage-adjustment, so as to carry the opal slowly from left to right, the spiral line is seen to revolve and roll over, altering its shape and position in the spectrum. It is not easy to retain the conviction that one is looking merely at a band of deficient light in the spectrum, and not at a solid body, possessing dimensions and in actual motion. No. 3 gives a line between the yellow and green, vanishing to a point at the top, and near the bottom having a loop, in the centre of which the green appears. Higher up, in the green, is a broad green band, indistinct on one side and branching out in different parts. No. 4 gives a broad, indistinct, and sloping band in the blue, and another, still more indistinct, in the violet. No. 5 gives a band in the yellow, not very sharp on one side, and somewhat sloping. Upon moving the opal sideways, it moves about from one part of the yellow field to another. In one position it covers the line D, and is opaque to the sodium-flame of a spirit-lamp. No. 6 gives a curiously shaped band in the red, very sharp and black, and terminating in one part at the line D. In the yellow there is a black dot. The spectrum of this opal showed by reflected light intensely bright red bands, of the shape of the transmission bands. On examining this opal with a power of 1 inch, in the ordinary manner, the portion giving this spectrum appeared to glow with intense red light, and was bounded with a tolerably definite outline. Without altering any other part of the microscope, the prisms were then pushed in so as to look at the whole surface of the opal through the prisms, but without the slit. The shape and appearance of the red patch were almost unaltered; and here and there over other parts of the opal were seen little patches of homogeneous light, which, not having been fanned out by the prisms, retained their original shape and appearance. No. 7 gives a black patch in the red, only extending a little distance, and a line in the yellow. On moving the opal the line in the red vanishes, and the other line changes its position and form. No. 8 gives the most striking example of a spiral rotating line which I have yet met with. On moving the opal sideways the line was seen to start from the red and roll over, like an irregularly shaped and somewhat hazy corkscrew, into the middle of the yellow.

Effects of Induction-currents on Amœba diffluens and Arcella vulgaris.—Some curious experiments have been made on these animals by M. T. W. Engelmann, and were recently reported to the Royal Academy of Sciences of Amsterdam. The animals were placed in a gas-chamber contrived with electrodes for the purpose, and the results were watched with the microscope. The following are some of the

results :—The course of the phenomena following the irritation of a single interrupted discharge from the coil is, says the author, determined by the intensity of the current and the condition of the protoplasm previous to the excitation. When the Amœba is acted on by the current, it is seen—when the animal has an elongated form, and moves with a regular velocity (0·01 to 0·2 mm. per second)—that the following events occur. A. *In Case of Feeble Irritation.*—After a short period of latent action, or even very rapidly, there is a sudden slackening or suspension of movement on the part of the granulations of the protoplasm, without any appreciable change of form on the part of the animal. In a few seconds more there is a gradual re-establishment of the current, and of the displacement of the granulations in the primary direction, without change of form on the part of the animal. Total duration of action, five seconds, maximum. B. *In Case of a Medium Degree of Irritation.*—Period of latent action hardly perceptible. Immediate arrest of granulations without change of form on part of animal. In about three seconds more there is a change of form (contraction) on the part of the animal, consisting in shortening and thickening of the Amœba (assumption of spherical form). During these changes the anterior part of the animal remains fixed by adhesion to the glass. The assumption of the spherical form is the more complete and rapid as the current is stronger. The time of contraction in case of feeble irritation may be about two seconds. The maximum of shortening may last for some time. Moreover, when the irritation has been very feeble, the granulations immediately recommence their circulation, and produce lateral expansions of the protoplasm. One of these expansions progressively increases, till it absorbs the total mass of the protoplasm, which thus being restored to the primitive elongated form, begins to move with regularity. The total duration of action is from about ten to fifteen seconds. C. *In Case of a Powerful Irritation.*—Here there is immediate arrest of the course of the granulations and commencement of contraction, which in about two seconds produces the maximum degree of shortening, that is to say, the more or less complete spherical form. After from half a minute to a minute and a half there is a re-establishment of the movement of the granulations, and formation of lateral expansions. In about two minutes the original condition of things is restored. When the Amœbæ experimented on are large and flat, and provided with short expansions, the effect of irritation differs according as a single shock or a series of shocks is given. The first action still consists in an arrest of the movement of the granulations, and of a very slight contraction. Soon after the Amœba becomes elongated nearly to a cylinder, and moves very rapidly in one direction, almost without change of form. Meanwhile, if the irritation is renewed, there is again an arrest of the granulations, and contraction takes place. The phenomena exhibited by *Arcella vulgaris* under the influence of electricity are, says M. Engelmann, best seen when the animal encloses a number of air-bubbles at the moment of excitation. The specimens best suited for observations of this kind are those which swim at the surface of a drop of water, the dorsal surface being next

the glass which forms the upper part of the gas-chamber. In such cases the air-bubbles preserve their size and form for a long while; at the same time the protoplasm is extremely mobile, and its expansions are frequently disappearing, like a dissolving-view. The form of the air-bubbles is irregular, being never perfectly spherical. When a current—that formed by making contact—is passed through the drops, the immediate, or nearly immediate, result is, that the bubbles of air become perfectly spherical, or—in places where the "test" prevents them—spheroidal, and the protoplasm withdraws a little from the inner surface of the "test." After a while—from one to ten or twenty seconds—the form of the vesicles becomes irregular, the protoplasm recommences its movements, and the protuberances reappear. After some minutes further, the bubbles of air become smaller and smaller, and the *Arcella* descends. Soon, however, in about half a minute, the bubbles become enlarged again, and the *Arcella* reascends. M. Engelmann says the experiment may be repeated several times with the same results. The author concludes his remarks by saying:—"From the fact of the bubble of air becoming spherical during the contraction due to the electrical action, it follows that the protoplasm during its contraction obeys the mechanical laws of liquids. The air-bubbles in becoming spherical do not apparently alter their volume."

The Development of Acaridæ.—At a recent meeting of the Royal Academy of Belgium, M. Van Beneden read a letter which he had received from M. Bessels, of Stuttgard, relative to the above subject. The substance of the letter was briefly as follows:—"The embryogeny of the Arthropoda had been very little studied up to the year 1863. But since the appearance of Weissman's work on the development of the Diptera, the subject has received more attention, and has been especially brought out by the memoirs by Mecznikow and Dohrn; and lately I have received from my friend Dr. Alexander Brandt, of St. Petersburg, a memoir published by the Academy on the subject of the development of the *Libellulidæ* and Hemiptera, in which the author deals especially with the embryonic membranes. For some time I have devoted attention to the development of *Atax*, *Phytopus*, *Sarcoptes*, *Tetranychus*, and other kindred genera." The writer then observes that his observations entirely agree with those of Claparède, published in a late number of Siebold and Kölliker's *Zeitschrift*, and he states that his results do not accord with those of M. Van Beneden. "I have," he says, "been equally unsuccessful, with Claparède, in not finding the germinal vesicle in ova recently deposited, as you have announced in your researches on the development of *Atax ypsilophorus* (p. 18). Doubtless it escaped my observation owing to the deep colour of the vitellus. Having never observed the ovarian eggs, it seems to me impossible to decide whether the membrane which surrounds the vitellus is a vitelline membrane or a chorion. I have been fortunate enough to observe the mode of formation of the blastoderm, which both you and Claparède missed. It would be hard to say how soon the blastoderm appears before the ovum leaves the oviduct, since the deposition of the ova has not been observed. In ova taken from the mantle of *Unio* and *Anodon* I have seen the blastoderm appear in from one to two days. If one of these ova be opened cautiously in a solution of one per cent.

of bichromate of potass, it will be seen that the blastoderm does not exhibit itself over the whole surface of the egg, but that it appears in islets. On account of the deep colouration of the vitellus it is impossible to view this phenomenon satisfactorily without destroying the ovum. After the blastoderm has extended around the yolk, the embryonic membrane detaches itself from it. It is this membrane which you have regarded as formed by the division of the primitive envelope of the ovum, and which Claparède has designated under the name of *deutovum*. I consider it to be the homologue of the larval membrane [Larvenhaut] of Crustacea, and this is evidently the homologue of the amnios of insects. I hope to demonstrate this more fully in a memoir on the amnios of Arthropoda which I hope to publish soon. It is in a short time after the formation of this embryonic membrane that we see appear between it and the blastoderm the first amœboid cells that Claparède thought arose at a later period. When in my work I designated these amœboid corpuscles under the name of blood-globules, I desired merely to indicate their relation to the cells of the blastoderm which at the date of the appearance of these *hæm-amœbæ* are the only cellular formations of the ovum. It seems to me that we shall have to admit two modes of origin of blood-corpuscles. In certain ova that I have watched through their entire period I have never seen any of these amœboid cells penetrate into the interior of the ovary. Claparède asks if you have not taken the parasites of *Anodon* for those of *Unio*, or, rather, if they are not the same animals which live in Belgium on *Anodon*, and in Geneva on *Unio*. In commencing my researches I placed a hundred Anodons collected from the neighbouring pools in a locality with running water, where I subsequently placed the *Unio batavus*. Four weeks after the two had been placed side by side, I found—as I have since frequently done—the parasite of *Unio* on *Anodon*, and *vice versâ*. It is hardly possible to confound the two parasites, as those of *Unio* have five suckers on each side of the ventral orifice, and those of *Anodon* have from thirty to forty." Such being the substance of M. Bessels' letter, the following is that of M. Van Beneden's reply:—"The disagreement which the writer points out has no real existence, since I declared distinctly that I had examined only the ovarian eggs. What I said was, 'the germinal vesicle is relatively larger as the egg is younger.' I am astonished that MM. Bessels and Claparède did not perceive that I spoke of the composition of the ovum before deposition. As to the *Atax*, which M. Claparède supposes to proceed from *Unio* rather than *Anodon*—which I shall send him alive if he wishes—all those used in my researches were taken from the same locality in the neighbourhood of Louvain, and where I have never seen any but *Anodon*. For the rest, M. Bessels' observations show that the same Atax may live on both mollusks. I would remark, in conclusion, that the amœboid cells which appear around the blastoderm seem to be perfectly analogous to those pretended parasites which appear in the same conditions on different mollusks, and which Nordmann* has named *Cosmella hydrachnoides* in *Tergipes Edwardsii*."

* 'Ann. des Sci.,' 1846, vol. v., 3^{me} Série.

NOTES AND MEMORANDA.

Preserving Insects.—A writer in one of the American journals states that the ravages of the beetle *Dermestes lardarius* may best be arrested by placing a few crystals of carbolic acid in the cases. He states that the evaporation from them will kill all insects in the vicinity.

Trichina spiralis—A Prize Essay.—The following notice of the Boston Natural History Society may interest those engaged in the investigation of Entozoa:—By the provisions of the late Dr. William J. Walker's foundation, two prizes are annually offered by the Boston Society of Natural History for the best memoirs, written in the English language, on subjects proposed by a committee appointed by the council. For the best memoir presented, a prize of sixty dollars may be awarded; if, however, the memoir be one of marked merit, the amount may be increased, at the discretion of the Committee, to one hundred dollars. For the memoir next in value a sum not exceeding fifty dollars may be given; but neither of these prizes are to be awarded unless the papers under consideration are deemed of adequate merits. Memoirs offered in competition for these prizes must be forwarded on or before April 1st, of the year specified below, prepaid, and addressed "Boston Society of Natural History, for the Committee on the Walker Prizes, Boston, Mass." Each memoir must be accompanied by a sealed envelope enclosing the author's name, and superscribed by a motto corresponding to one borne by the manuscript. Subject of the Annual Prize for 1870, "The reproduction and migration of *Trichina spiralis.*"

Browning's Miniature Spectroscope.—We have had this marvellously cheap and handy pocket-spectroscope in use for some time, and find it answer most of the purposes for which the spectroscope is employed. It is especially useful for the examination of the absorptions produced by certain coloured (and colourless) fluids. We especially commend it to the physician. In the out-patients' room of an hospital, where it is difficult to employ a microscope for the detection of blood in urine, this little instrument of Mr. Browning's will afford the means of diagnosis almost in a moment. In optical qualities it leaves—considering its small size, which enables it to fit in the waistcoat pocket—little to be desired.

PROCEEDINGS OF SOCIETIES.*

Quekett Microscopical Club.†

On the 23rd of June, the annual excursion of the club took place. Five-and-twenty members proceeded by train to West Humble, in Surrey, where they alighted. They strolled thence over Box Hill and the adjacent country; the exceeding fineness of the day greatly enhancing the beauty of the scenery in which the locality abounds, and adding materially to the enjoyment of the excursionists.

After having rambled to their heart's content, they returned to Leatherhead, where they were joined by several other members of the club with their friends, and the whole, numbering fifty-one, sat down at 6 o'clock to an excellent dinner provided by mine hostess of the "Swan," the chair being occupied by the President. A most social and agreeable evening was spent, much satisfaction being expressed with the arrangements made by the excursion committee (Messrs. Arnold, Gay, Reeves, and Suffolk), to whom the cordial thanks of the guests were given.

The Fourth Annual General Meeting was held on Friday evening the 23rd July, in the Library of University College; Mr. Arthur E. Durham, President, in the chair. A report was read which showed that 142 members had been elected since the last annual meeting, making a total of 512. The Treasurer's report showed that the finances were in a very satisfactory condition. In vacating the chair, which he had filled for two years, the President delivered a highly impressive address, which was listened to with marked attention throughout. The following gentlemen were elected to fill the offices named during the ensuing year:—President, Mr. P. Le Neve Foster; Vice-Presidents, Dr. R. Braithwaite, Mr. W. M. Bywater, Mr. A. E. Durham, and Mr. H. F. Hailes; Members of Committee, Mr. T. Crooke, Mr. B. T. Lowne, Mr. S. J. M'Intyre, and Dr. J. Matthews; Treasurer, Mr. R. Hardwicke; Hon. Secretary, Mr. T. Charters White; Hon. Secretary for Foreign Correspondence, Mr. M. C. Cooke. A paper "On the Ratio-micropolariscope," by Mr. James J. Field, its inventor, was read, at the conclusion of which the instrument was exhibited. Ten new members were elected, after which the proceedings terminated.

Brighton and Sussex Natural History Society.

July 8. The President, Mr. Glaisyer, in the chair. Papers were read by Mr. T. W. Wonfor, Hon. Sec., "On the 15th Annual Excur-

* Secretaries of Societies will greatly oblige us by writing out their reports legibly—especially the technical terms—and by "underlining" words, such as specific names, which must be printed in italics. They will thus ensure accuracy and enhance the value of their proceedings.—Ed. M. M. J.

† Report supplied by Mr. R. T. Lewis.

sion," and by Mr. J. Robertson on Professor Owen's General Conclusions, in which his ideas on the origin of species and life were criticized.

It was resolved that the Hon. Secretaries be instructed to communicate with the town authorities, and see in what way the co-operation of the Society would be most effective to induce the British Association to visit Brighton.

Birmingham Natural History and Microscopical Society.*

The following papers were read at the meetings of this Society, held during the month of May :—

By Mr. A. Simcox, " On the Geology of North Gloucestershire."

By Mr. E. J. Chitty, " On the Desmidiaceæ, with Notes on their Collection and Cultivation;" being an account of observations as to their mode of growth and reproduction extending over the past four years (for which period the author has successfully maintained a considerable number of species in a healthy state under artificial conditions), together with practical hints as to the best means of collecting, cleaning, and preserving them.

By Mr. E. Myers, " Notes on the Gulf Stream."

By Mr. E. Simpson, " On Insect Anatomy and Classification," a valuable practical paper, commencing with an analysis of the various systems which have been adopted by different naturalists; and proceeding to a description of external insect anatomy and its application to the classification now generally adopted. The paper was illustrated by a fine collection of specimens and of microscopic preparations.

At the same meeting the secretary of the geological section gave an account of a very successful excursion of its members to the villages on the west side of Wolverhampton, resulting in a large addition to the map of the glacial features of the district, upon the construction of which on a large scale the section is now engaged, and in the discovery of a considerable number of crystallized minerals imbedded in boulders, and including hornblende, garnets, &c.

During the same month most departments of Natural History have been well represented on the evenings devoted to the exhibition of specimens—the season of course favouring the display of botanical treasures. These comprised *Smyrnium olusatrum* and *Knappia agrostidea* from Jersey, contributed by Mr. C. Adcock; *Saxifraga tridactylites* from Knowle, and *Gymnogramma leptophylla* from Jersey, *Narcissus biflorus* and other plants from Moseley, by Mr. Crofts; *Paris quadrifolia* from Alvechurch, by Mr. Morley; *Thlaspi perfoliatum* from Tetbury, the rare moss *Amblyodon dealbatus*, &c., from Sutton, by Mr. Bagnall; by Mr. J. Lamb, *Fritillaria meleagris* from Reading; by Dr. Griffiths, *Opergrapha amphotera* from Cader Idris, and many other rare lichens; by Mr. Marshall, *Orchis militaris*, *O. ustulata*, *Ophrys muscifera*, and *O. aranifera*, from Wye Downs; and a great variety of other specimens either absolutely or locally rare.

* Report furnished by Mr. A. W. Wills.

Conchology was represented by Mr. Nelson, who produced a fine collection of foreign land-shells; and Mr. Tye, who exhibited a number of freshwater shells from various localities in North America; and others. The entomological specimens were good, but small in number on account of the unusual inclemency of the weather. The zoological comprised *Halithœa aculeata* from Torquay, sent by Mr. W. H. Harper; a very complete collection of British birds' eggs, by Mr. W. Wilson; an excellent and well-arranged cabinet of insects, by Mr. Simpson, &c.

The interest in the microscopical branch of the Society has been fully sustained, and from a large number of specimens exhibited by its members the following may be mentioned:—

By Mr. Bolton, a fine collection of *Rotatoria*, including *Dinocharis pocillum*, *Euchlanis triquetra*, *Brachionus urceolaris*, *Synchœta pectinata*, *Limnias ceratophylli*, and other species; by Mr. Graham, *Euglenæ*, active and encysted; by Mr. Parsons, various species of *Vaucheria* and *Batrachospermum*, very finely in fructification; by Mr. Tye, the beautiful Polyzoon, *Bowerbankia imbricata;* by Mr. Shoebotham, a singularly fine series of preparations produced by a new mode of manipulation, and including tissues showing the stomata of *Ilex aquifolium*, *Agraphis nutans*, *Agave Americana*, and many other plants; by Mr. Wills, *Vaucheria Dillwynnii*, *V. ovoidea*, *V. ornithocephala*, *V. repens*, *V. sessilis*, *Closterium acerosum* in conjugation, and a remarkably rich gathering of *Volvox globator*.

Microscopical Society of Liverpool.

The sixth ordinary meeting was held at the Royal Institution, on Tuesday, 1st June, Dr. Nevins, President, in the chair. A lecture was delivered by Dr. Thomas Inman, one of the Vice-Presidents, on the Natural History and Microscopical Characters of Hairs. Dr. Inman first called attention to the utility of prosecuting any microscopic or other subject of study as far as possible, remarking that such investigation showed that in almost every animal and vegetable structure there was general resemblance, but individual difference. The tongues of the mollusca were marked in the same way as regards plan, but in detail each variety had a tongue so peculiar to itself that a doctor might say to it, Show me your tongue, and I will tell your name. A similar statement applies to hairs. The observer readily distinguishes butterflies and moths as such by their scales, and the birds by their feathers; but a closer observation enables him to name the particular genus from which a particular scale or feather comes. It would be impossible in a short essay to describe all forms of those appendages of the skin to which the names of scales, feathers, hairs, wool, &c., had been given. He therefore would confine himself chiefly to a description of the general characters of animal hairs. The most simple form of hair was found in butterflies and the insect world. In them was to be seen a long hollow pointed cylinder attached to and forming part of the skin. This might be compared to the central stem of a bird's wing-feather. In some creatures this stem became

branched, and in others the offshoot became still further branched, as in pinion feathers, where the original branches had curved branchlets which intertwined with each other so as to prevent their separation. In others the simple hair became forked like the letter Y, and the space between the branches became filled up to form a scale. In the hair of mammalia there were three parts to be noticed—an outer scaly covering (a continuation of the epidermis), a fibrous material growing from a special matrix, and somewhat analogous to nails and hoofs, and a central cellular growth.

(*To be continued.*)

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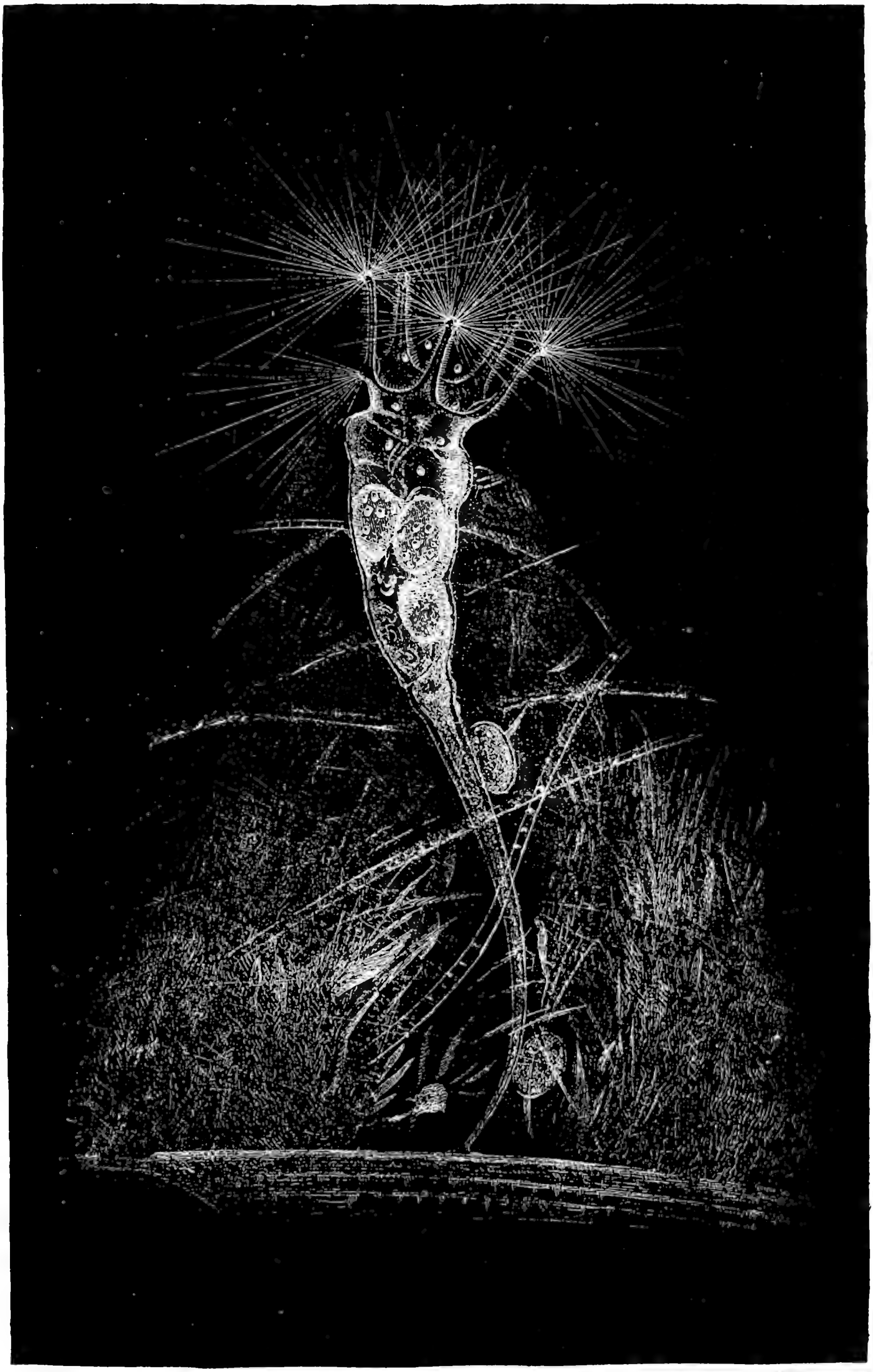
Note pour servir à la faune de la Gironde, contenant la liste des animaux marins, dont la présence à Arcachon a été constatée pendant les années 1867 et 1868: par M. A. Lafont. Bordeaux. Degréteau.

Rapport sur l'ostréiculture à Arcachon, Hayling, et Trieste; par M. le docteur Soubeiran. Paris. Victor Masson.



W. West imp

THE

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I.—*Micro-spectroscopy.—Results of Spectrum Analysis.*

By Jabez Hogg, F.L.S., Hon. Sec. R.M.S., M.R.C.S., &c.

(*Read before the* Royal Microscopical Society, *June* 9, 1869.)

When we look back upon an important discovery in science, how frequently it occurs that a great fact wholly unexpected is presented to us, and even unconnected with the subject which had engaged the attention of the explorer. It has been so with spectrum analysis, the origin of which may fairly be referred to Newton's discovery of the composition of the solar spectrum. This physical phenomenon, made known to the world more than two hundred years ago, led to the inquiries which step by step have conducted us to the most delightful and wonderful discoveries of the age.

The rise and progress of spectrum analysis are known to most of the Fellows of the Microscopical Society; it is therefore unnecessary for me to trouble you with any preliminary observations connected with either.* I am, however, desirous of directing your attention to that very interesting field of research immediately connected with the colouring matter of flowers, the composition of which, and the part played by the action of light in its formation, is left for spectrum analysis to reveal. It is my purpose on the present occasion to make some observations upon the results obtained in the preparation of the colouring matters for spectroscopic examination. I must also request you to receive my paper as one suggestive of a subject to those whose opportunities and leisure are greater than my own, trusting it may prove to be a finger-post

* It is simply necessary to remark that this paper was preceded by a few introductory observations on spectrum analysis of a general and historical character, but which were not intended for publication. I purposely confine myself to original observations on the colouring matter of flowers, which have more particularly engaged my attention. With regard to certain remarks, purporting to be a criticism on my paper which appear in the Proceedings of the Society (June meeting), they are so perfectly irrelevant and discourteous to me, personally, that I must decline to answer them.

pointing the way to an interesting department of physical science, in which the microscopist equally with the chemist may reap a rich harvest.

It is a generally received opinion that the chromule of flowers is due to the chemical action, actinic rays, of light on the juices or protoplasm of the plant during growth. It is known, however, that the powerful action of light, in some instances, tends to decolorize flowers: therefore the gardener screens his choice tulip from the direct rays of the sun. It is evident that the phenomena associated with the formative colour process, which lends so much beauty to the floral world, is only half explained by the light hypothesis. Besides light, there must be other forces at work which enable the plant to separate from the soil, or select from within its tissues, certain constituents, of which we know little, such as those stored up in the woody material of the stem or root, yet so far removed from the presence of light that they appear associated with it only in a small degree. In such situations are found very large quantities of colouring matter, differing in character to that of the petals; the stem or root, at first green, becomes brown, red, or black, and ultimately forming dye-woods, which are of so much importance in a commercial point of view.

No doubt light is an indispensable agent in the production of the cromule of flowers; and the curious part of the change is that it should be so diversified in the petals, imparting to them brilliancy and variety of the most perfect and pleasing character. The modifications of tints are supposed, in a measure, to be owing to the nature of the cuticle through which the colour in the interior of the petals is viewed; if the colour is more or less yellow it is modified by the character of the more superficial cells. This, however, offers no explanation of the colouring matter found in the roots, and which must differ in its nature with the chromogen of the petals. It is remarkable to notice that although certain plants, as the beetroot, readily yield up their colour to water, nevertheless during the state of health and vigour they seldom part with any considerable portion of it to the soil in which they grow, not even during long-continued rains. The alkanet, the root of which is the great storehouse of colour, will not, under any circumstance, part with it to water. Spirit, oil, and turpentine are its particular solvents. Will not spectrum analysis enable us to solve some such mysteries in vegetable physiology, or explain the optical and physical differences of two bodies growing on the same stem?

The colours of flowers, botanists tell us, may be arranged in two series, the zanthic or yellow, and the cyanic or blue, while red is common to both, and green intermediate. The red colour of certain leaves is owing, it is thought, to an excess of acid in their juices. This fact appears to receive support from the circumstance

that the red leaves of autumn partially recover their green colour when subjected to the fumes of ammonia. The calorific ray of the spectrum has probably more to do with the formation of acid than the actinic ray. I have noticed in the garden rhubarb that when leaves are more exposed to heat and light they become quite red; when tested, the acid reaction of such leaves appears to be increased; the solutions obtained from them are of a deeper red colour, and produce the same absorption of the spectrum as the more decided red solutions obtained from flowers. Most vegetable blues are changed to reds on the addition of an acid, thus showing the apparent connection between the relative amount of acid in the composition of the colour. It does appear, then, when colour is taken alone it affords no conclusive information respecting the chemical properties on which it depends. The same tint may be made up in an infinite variety of ways from the constituents of white light.

Starting from green, which may be taken as a state of equilibrium between blue and yellow, the colour quickly deepens, and passes through blue and violet to red. This change is due to oxidation; while the transition from red to yellow may be regarded as a deoxidizing, or reversing process. Modifications are produced by the retention of a larger proportion of carbonic acid, by the predominance of an acid, an alkaline state, or the presence of nitrogen which accelerates the absorption of oxygen; and when in contact with ammonia, nitrogen may assist in the production of a blue or violet colour.

With regard to the formation of colour, this must be considerably modified, or accelerated by the presence of oxygen. Plants while liberating large quantities of oxygen retain in their juices much of the same gaseous matter; and it is a well-established fact that intensity of colour in no small degree depends on the absorption of oxygen and the quantity plants are able to store up,—in other words, upon their oxidizing power. The oxidizing process is greatest during sunlight, when another element also comes into play and exercises some influence, that received from the sun's rays and stored up as heat, and rendered latent, in the form of cellulose or wood, fixed and volatile oils, &c. Latent heat is undoubtedly an important accessory in many ways; as in the formation of the saccharine, starchy, and albuminous principles—the ammonia and water derived from the soil being necessary ingredients—and in the colour-making process, especially when colour is to be stored up in the roots of plants.

In order to observe coloured matters of any kind with any degree of certainty they must be examined in a pure spectrum, and to do this effectually the material must be so placed that it shall intercept a beam of light which forms the spectrum, and when well-defined reactions of coloured solutions or materials have once been

carefully ascertained, with special reference to certain lines in the spectrum, there will be no difficulty whatever in tracing them again, even should they be disguised by the presence of other substances.

So far as I can ascertain respecting the colours of flowers, none possess the property of perfectly homogeneous simple colours, as all permit more or less of different colours to pass. If any had a single colour only, the spectroscope would allow that one to pass, while absorption of the rest of the spectrum would occur. Various parts of flowers yield differently-coloured solutions, which give varying results in the spectrum.

All coloured solutions appear to have a limit set to their dilution; when this is transgressed no reaction is produced on the spectrum. This limit may be ascertained by experiment, and testing the effect on the spectrum. For this reason it is necessary to submit various thicknesses or strata of the coloured solutions to the micro-spectroscope, otherwise points of interest will be missed. For the examination of vegetable fixed oils the test tube should not be less than an inch and a quarter in diameter. Density of colour is in most cases the guide for the determination of this point.

If the prisms are not carefully adjusted or arranged, unequal dispersion of the spectrum is produced. There is also usually a difference between the length and intensity of the bands, generally the blue end is twice as long as that of the red; and although narrowing the slit in a measure corrects this, it will not do so to any considerable extent. As every part of the band differs in refrangibility, the delicate lines produced by some solutions can only be brought out by accurately focussing that particular part of the spectrum in which they often too faintly appear.

The rack and pinion motion in the eye-piece must be fairly brought into use, and the results observed with artificial light should be corrected by daylight. Bands in the red end of the spectrum are best brought out by artificial light, while those in the blue or violet are better observed by daylight. It not infrequently happens that with some kinds of daylight admitted into the apartment its chemical composition is sensibly affected, the Fraunhofer line D appears, or even a series of bands which convey delusive appearances: this must be guarded against.

Provision is made in well-adjusted instruments for the correction of some of the evils spoken of. It is only proper to say that the spectroscope I use is the Sorby-Browning direct vision, which has the necessary appliances for obtaining careful adjustment, and is in every way the most convenient form of instrument.

Mr. Browning has, with his usual ingenuity, lately constructed a small and portable form of instrument, which can be carried in the waistcoat pocket. It is cheap, and can be employed either with or

without the microscope; the dispersion obtained with this small instrument is remarkable. A description of it appears in the August number of the Journal, page 65. Mr. Crookes exhibited at a late meeting of the Royal Society a spectroscope adapted to use with the binocular microscope, which he said had been devised to obviate the disadvantages of the ordinary micro-spectroscope.

The instrument is described in the June number of the Journal, page 371. I would observe, it appears to me to differ in no very essential particular from one constructed by Mr. Browning two or three years ago, and which was soon after abandoned. I am not at all surprised that it should have been thrown aside, as it occurred to me at the time that its disadvantages counterbalanced its advantages. The defects of that of Mr. Crookes are that it requires the addition of a substage to carry the condenser, slit, and reflecting prism, and also a box to hold the dispersion prisms. The prisms and slit being attached to different parts of the microscope, the apparatus is more likely to get out of order than that of the Sorby-Browning, in which the prisms are fixed in their required and relative position in the eye-piece. The microscope must be sent to the maker of the spectroscope; certainly a disadvantage, when by cutting out a piece of cardboard into which an eye-piece fits is all that is required for the purpose of adapting the "direct vision Sorby-Browning instrument."

Mr. Crookes refers to the convenience his form of spectroscope possesses over others, in enabling observers to use it with a binocular microscope; it should, however, be borne in mind that the light is much degraded by passing through a narrow slit, and is then spread out by the fan-like action of the prisms, and that many lines which may exist in the deep-blue of the spectrum will probably be lost or passed over unrecognized, particularly if the light be divided between two eye-pieces. Mr. Crookes forgets, also, that the best results are those obtained with a limited amount of dispersion. Substances which show several fine absorption bands with a low dispersive power, appear to be without lines when a higher dispersive power is employed. A solution of chloride of cobalt in chloride of calcium will show this most conclusively. Not the least important part is, that the whole apparatus will be necessarily much more costly.

An interference spectrum is employed by Mr. Sorby for the purpose of dividing the spectrum into regular intervals, for the convenience of facilitating a careful record of the results obtained. This, in the form proposed by this gentleman, is not unattended with disadvantages, when reduced to practice. If considered necessary to employ an artificially divided scale for reference, in place of the now universally adopted Fraunhofer's lines, it will surely be better to make use of a natural material, as Zircon, discovered by

Professor Church, which when cut at the proper angle gives a series of unvarying and equally divided bands throughout the spectrum. This mineral substance is even preferable to the nitric oxide gas of Brewster, which was proposed for the same purpose some time since by Dr. Thudichum;—claimed lately by the editor of the 'Quarterly Journal of Microscopical Science' as quite a new discovery of his own. The spectrometer devised by Dr. Thudichum for his laboratory experiments, St. Thomas's, enables him to obtain a scale divided into 2000 divisions of the colour spectrum.*

At the present moment nothing has been satisfactorily proposed for a systematic grouping of the colours; but it seems to me that a preference should be given to the proposal for making the order of the bands the basis of our future arrangement. Take the normal chlorophyll band, when that has been definitely fixed, as group 1; then a Tauracine band; the permanent three bands of red cinararia; the six of Berberis; and those producing general absorption might form a distinctive group; but it would certainly be preferable to refer to the absorption bands of chemical salts or minerals, as these are more constant. After this has been fairly done, may we not hope so to generalize the facts as to apply the knowledge obtained to some useful purpose, as that arrived at by Professor Roscoe in determining the spectrum of the Bessamer process in making steel?

In the preparation of the colouring matters of flowers, it is of less importance to attempt to get rid of any excess of acid that may exist in their petals, than it is when it is wished to extract the pure and simple chlorophyll of the leaves of plants, the object being that of obtaining the colouring matter in its intensest and purest form. To effect this, steeping the petals in water will not serve the purpose, as only very few flowers thus part with more than a portion of colour. In some instances it appears to produce what may be described as a decomposition; depriving flowers of their chromule, and leaving behind only a colourless solution. Spirits of wine is certainly the most efficient and widely useful menstruum for the purpose of extracting chromule and retaining it unchanged for any length of time. I have found methylic, or wood spirits, bisulphide of carbon, chloroform, glycerine and spirit, all useful agents; but although spirits and water are the chief solvents of vegetable colours, it frequently happens that they are not equally efficient: there is consequently a good deal of variation in the spectrum results.

In the preparation of coloured solutions, I find it better not to crush the petals or leaves previous to immersion in the spirit or water. Crushing often changes the colour, and, as a rule, it is

* 'The Chemical Identification of Disease,' by Dr. Thudichum. Tenth Report Public Health, p. 192. 1868.

quite as readily extracted without resorting to this process; another advantage is gained, inasmuch as clear transparent fluids are obtained without incurring loss by filtering through blotting-paper. Occasionally it is seen that spirits affect results, by the extraction of the gum resin and essential oil of the flower along with the colour; but this is not a very grave evil, nor does it appear to be necessary to strain away the pollen grains, which are at times suspended in considerable quantities; indeed, this will be found to be an excellent way of collecting and preserving the pollens for microscopical examination. A little pure simple syrup should be added to the solutions before the tubes are filled and hermetically sealed.

The pure vegetable and animal oils, which in themselves produce no reaction on the spectrum, may in some instances be employed with advantage for the extraction and preparation of colouring matters. The fine colour of *Anchusa tinctoria* (Alkanet-root) is readily extracted by any kind of oil; in this menstruum it becomes a fixed colour, and a much finer series of spectrum bands are obtained. An oil that in no way affects the spectrum, as expressed castor-oil, or purified cod-liver oil, should be employed for the purpose of dissolving out the colour of alkanet-root. A good almond-oil coloured pink by alkanet-root gives a fourth and fifth band in the blue and violet. It is curious to watch the reactions produced in the spectrum by the combination of various fixed oils with this colouring matter; with ordinary flask olive-oil, the chlorophyll band of the oil itself seen in the red is exaggerated, as well as the second band in the blue, and the violet is wholly absorbed; castor-oil gives an extra band in the indigo; cod-liver oil augments the blue end of the spectrum, and develops a third band in the blue. The vaunted Macassar-oil, supposed to be prepared from roses, evidently owes its colour to alkanet-root, as it produces the same series of bands as are produced by alkanet-root in olive-oil. When to a small quantity of spirituous solution of alkanet-root lime-water is added, it changes to purple-pink, or red; the absorption bands are well marked, especially those between C and D, and D and E; but the lines do not appear exactly in the same portion of the spectrum indicated by Mr. Sorby in his experiment with carbonate of soda. This solution, like his however, is not permanent, and with the change of colour the absorption bands disappear. If to a pink-coloured spirituous solution simple syrup is added, the red end of the spectrum is greatly augmented; the two bands in the green are sharply defined, and that in the blue is wider, while the violet is completely absorbed. Although the sugar crystallizes out and falls to the bottom, the colour does not fade. A solution of a bright pink appears to be the best tint for observing the reactions of the anchusa-root, and the employ-

ment of transmitted or reflected light produces a marked change in the spectrum of this substance, as well as in that of many others.

A very large number of the petals of flowers yield solutions closely resembling the dilute solutions of alkanet in spirit, so that in the ordinary way it is difficult to determine the difference between them. The spectrum of alkanet-root at once removes a doubt; but so much cannot be said for a number of other red or crimson solutions. The brilliant damask rose, when immersed in water, loses all its colour; which is at once restored on adding a drop of sulphuric acid. A fine pink is obtained, which is permanent, by diluting with glycerine and spirit. This heightens the red end of the spectrum, producing a brilliant halo of red light; the rest of the spectrum is absorbed; or, if a paler solution is used for examination, a broad absorption band occupies the green, and the blue of the spectrum is deepened. The crimson purple-coloured petals of fuschia lose colour by immersion in water or spirit and water, but a drop of acid at once restores the brilliant colour of the flower, and the solutions produce the same reaction on the spectrum as the red rose. From another variety of the fuschia, bearing white and red coloured flowers, a paler solution is obtained, which a drop of acid converts into a pink; but if an alkali be added the colour changes to a yellow, and no reaction is observed in the spectrum. Nasturtium petals produce a fine amber red, which changes into a crimson on the addition of an acid; and its reaction on the spectrum is the same as that of the damask rose. *Cactus speciosa* petals yield a fine crimson-coloured solution. Acid only very slightly deepens the solution, which augments the red; and a broad dark band occupies the yellow and green, while the blue becomes more intense. From the juicy leaf or stem of the *Opuntia cochinillifera,* upon which the cochineal insects feed, chlorophyll cannot be obtained in sufficient quantity to produce any reaction on the spectrum. A fine crimson colour is, however, extracted on digesting the Coccus cacti (cochineal insect) in distilled water, which produces a general absorption of the green, blue, and violet; but upon adding a small quantity of ammonia to the solution, the colour is changed to a lake or reddish purple, when two sharp bands appear in the yellow and green, and one in the blue; the violet is intensified. When liquor calcis is added to another portion of the solution it nearly approaches a violet, and produces a similar series of bands; on adding an excess of alum, the colour changes to a yellow, which absorbs the greater part of the green and blue.

The deep crimson colour obtained from the Pæony produces general absorption below the red; when a small quantity of liquor potassæ is added to the solution, this red colour is converted into a green, and characteristic bands appear in the yellow and green part of the spectrum; if the solution be pale enough, another line is

seen in the blue. The tint of this solution is not permanent; decomposition takes place, and the bands disappear. The red poppy is very similar in its reactions. The ranunculus gives a band in the red and orange, and deepens the rest of the spectrum. The solutions of the crimson petals of the geranium behave in a precisely similar way. The Iris imparts a fine reddish-purple colour to alcohol and water, the solution of which gives a band in the red, orange, and green, and partially absorbs the blue end of spectrum; the addition of citric or mineral acid deepens the colour of the solution, and destroys the several bands, producing a general absorption of one end of the spectrum; alkalies do not restore the bands in the spectrum.

Litmus, a well-known colouring matter, prepared from *Rocella tinctoria* (canary archill or orchill), and which yields a valuable dye, and is employed largely for dyeing broadcloth, to which it communicates a peculiar purple lustre when viewed in a certain light, is soluble in water and alcohol, to which it imparts a beautiful violet colour. This solution produces a fine band in the red, and another broad one which completely absorbs the orange and yellow and a portion of the green, while it deepens the violet end of the spectrum. Acids redden the solution and change the position of the spectrum; the red is rendered more intense, the orange and yellow are restored, and a broad band appears in the green and blue. Carbonate of soda restores the violet colour of the solution; at the same time the band in the red reappears, a separation of the green band takes place, and a faint one is produced in the blue.

Tradescantia virginica (Spiderwort), the jointed hairs of which show the circulation of the chlorophyll, so interesting to microscopists, yields to alcohol and water a reddish-purple solution, of the same colour as the flowers, the spectrum of which somewhat resembles that of *Lobelia speciosa*, but is more decided and curious. The red is intensified; sharply-defined bands appear in the yellow and green, and I believe in the blue; but owing to the exaltation of this end of the spectrum it is not quite easy to say. Larkspur yields a pale reddish-blue solution, and produces four absorption bands in the red, green, and blue; there is no action on the yellow, although the colour has a good deal of blue in its composition. Vegetable blues are not invariably acted upon by acid or alkalies. It does not follow that acid converts them into red, and alkalies into green. In Mr. Sorby's experience of the solution of *Cœsalpina crista* (Brazil wood), called yellow, but which when first acted upon by water forms a red solution, and turns yellow after standing some time, probably owing to a deoxidation of the solution, he observed that the yellow solution became pink on the addition of an alkali; Brazil wood, however, is used as a red dye, while from other varieties of the *Cœsalpina* black dyes are made, and even fine black ink. The yellow solution of this substance forms

rather an exception to the rule, as rarely in my experiments did yellow solutions appear to be materially acted upon by alkalies. Yellow rose-petals form a deep amber or orange coloured solution, which is brought nearer the yellow by carbonate of soda. The addition of either a vegetable or mineral acid produces little or no change in the colour of the solution, nor do they cause any absorption of the spectrum; caustic potash and liquor calcis deepen the colour, changing the solution to a greenish-yellow, but no corresponding change takes place in the spectrum. The Brazil wood solutions produce the absorption reactions of the reds; that is, both with its pink and red solutions there is an exaltation of the red; a broad band in the green, which some tints seem to divide into two; another in the blue, with a deepening of the blue and violet.

The yellow tulip solution is quite as much unaffected by reagents as that of the rose. From the tulip-petals a yellow crystalline matter is obtained, which no doubt is identical in its character with Dr. Thudichum's *Luteine*, which he says "shows three absorption bands in the blue violet and indigo portion of the spectrum, and are indicative of the presence of this body in yellow solutions."

I have observed that in a very great many instances solutions obtained from either flowers, leaves, or stems of plants, produce uniform results on the spectrum. The evergreen berberries with their pretty leaves, some of which are a reddish-green or deep purple, and produce an abundance of orange-red flowers, all yield solutions to both water and spirit, which give a most interesting set of absorption bands, at least six in number; the solutions keep well, and the spectrum is very permanent. The highly-extolled Peruvian Coca, the leaves of which are said to sustain the life of the aboriginal races for a long time, chiefly derive their nutritive powers from the large quantity of saccharine matter contained in them; from its flower or leaf a fine bright-green is extracted by either water or spirit, producing a sharply-defined set of absorption bands nearly resembling the berberry. I find that numerous different solutions yield an almost identical series of absorption bands, as the pine-apple, digitalis, hyoscyamus, senna, belladonna, laurestinus, buckthorn, &c. With Professor Stokes, I believe that spectroscopic examination of the constituents of plants and animals will certainly aid in their identification, "the force of the additional evidence being greater or less, according as their optical characters are more or less marked; or it will establish a difference between substances which might otherwise erroneously have been supposed to be identical."

The blue series of colours in flowers are exceedingly difficult to extract, they resist almost every solvent of other colours. I believe they have rarely been obtained in a pure form; but if a small quantity of red enter into their composition, then the colour is

extracted without much difficulty. Nearly all blue flowers yield yellowish or pinkish-yellow solutions. Alkalies deepen these colours and bring them nearer to green. Acids on the other hand mostly convert them into reds, they then produce the same effect on the spectrum as reds. The extraction of colour from the leaves of plants of a deep red, as Coleus, &c., appears to take place by deoxidation; on immersing such leaves in alcohol the red colour is quickly extracted, and the leaves become quite green; after standing by twenty-four hours the green becomes paler, and ultimately on decanting the solution the leaves are left colourless. Upon removing and drying them in the air a considerable portion of colour returns. The solution first obtained produces a more decided reaction on the spectrum than subsequent solutions, although the latter apparently contain a larger quantity of chlorophyll.

Most red solutions produce, as I have said, a general absorption of the spectrum below the red, but if properly diluted to a pink, they give two or more bands in the yellow and green, deepening the blue end. If a small quantity of blue enters into the composition of such solutions, bands will also be noticed in the blue, or the violet, and this portion of the spectrum will be seen to be more intense; good illumination and dispersion, as well as proper dilution, being indispensable to bring out the bands in the violet. The red end of the spectrum is at the same time often more brilliant.

A solution of Brazil wood, to which an alkali and alum had been added, remained of a yellow colour; but on dilution it became pink, and on standing in a strong light it changed to a deep red. This solution produced absorption of the whole of the green portion of the spectrum; but upon again diluting it down to a pink, a broad well-defined band appeared in the green and yellow, deepening the blue end.

Methylic alcohol requires caution in using. It is very liable to produce decomposition of the colour obtained, from the circumstance that the commercial spirit sold under the name of "Methylated spirits," is often contaminated by impurities. The fine scarlet cactus flower readily parted with its colour to methylic spirits, but it is soon changed to a yellow, and finally became colourless.

Memorandum of Spectroscopic Researches on the Chlorophyll of various Plants. By the late William Bird Herapath, M.D., F.R.S., F.R.M.S., &c.

The late lamented Dr. Herapath was actively engaged during the summer of last year in the study, by means of the spectroscope, of the optical characters of chlorophyll. At the time of his death he

had unfortunately written no paper on the subject, though he had had a diagram, exhibiting his leading results, lithographed and coloured, to accompany a reprint of the intended memoir after publication. This chart, with the following extract from a letter to his friend, J. E. Howard, Esq., of Tottenham, will suffice to rescue from loss Dr. Herapath's last scientific work.

Extract from Letter.

"*June* 27*th*, 1868.

. . . "I have found results of very considerable interest in the last consignment you sent me. There are three solutions of the chlorophyll of the Cinchona Succirubra. One in alcohol is *scarcely coloured*, having in fact *a tinge of olive-green.* This in the spectroscope was perfectly marvellous to me. It gave four well-marked absorption-bands, one deep sharp line *in the red;* another, rather narrower, in the orange, coincident with D, or the sodium-line; one in the green, about *b*, coincident with the Thallium green band; and a fourth on the blue line F, nearly as broad as that in the red. The ethereal solution gave different results. It showed only three bands of absorption, nearly the same as in the last case (though all of them fainter); but the fourth in the blue was not apparent, the whole of that end of the spectrum being absorbed a little beyond the green band *b*. This solution was *deep emerald-green*, and even on dilution did not alter its phenomena. The *acid* alcoholic solution was as deeply green as the last, but gave only the sharp broad absorption-band in the red, and two very faint ghostly bands in the position described above of the D and *b* lines respectively.

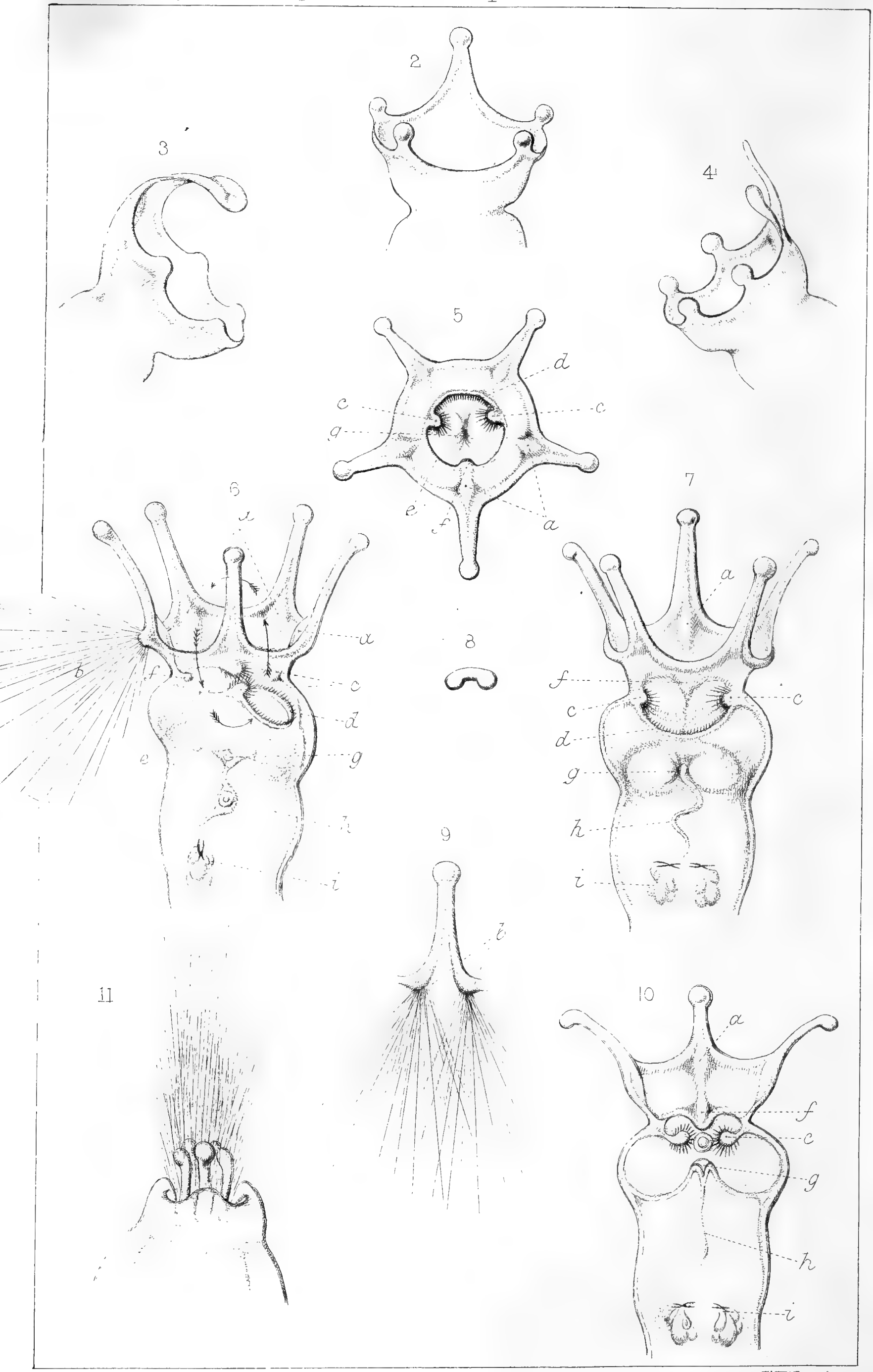
"Extensive additional researches on the chlorophyll of various plants have given some very extraordinary results, which I am now working out. The chlorophyll was dissolved out by *Spiritus Vini Rect.*, digested for some hours *in the cold;* some plants being fresh, and others dried.

"Five classes of phenomena exhibit themselves, but *all* agree in having the red absorption-band broad, sharp, and well-defined. Some have this one band only: the Lilac is of this type.

"There are two classes in which two absorption-bands occur. One has the red and the orange bands, of which the Fuschia, Guelder-rose, and Tansy are examples; another, in which the red and the green bands are alone coexistent. Ivy is the type of this class, and it is immaterial whether we take last year's leaves or those of the early spring; the results are the same.

"The fourth class consists of the two former spectra superposed. Three lines occur, the red, the orange, and the green bands, at C, D, and *b*, as before. This is by far the largest class, and I have thirty or forty examples of it. *Œnothera biennis*, Laurestinus, &c., are types, with the ethereal solution of the leaves of Red Bark.

"The fifth class consists of those having properties similar to the alcoholic solution of Red Bark before described. I have only found eight of these as yet, and not all equal in power, namely:—Berberry



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Structure of Floscularia coronetta.

(fresh); Sloe (fresh); Tea (dry); Hyoscyamus (dry); Senna (dry); Digitalis (dry); and Red Bark (alcoholic).

"I think you will agree with me that these are very important, interesting, and novel experiments, and well worthy of being followed up. I can arrive at no solution of these facts as yet, and cannot see *why solutions which have such equally green tints to the eye, should present such diverse optical effects.* There must be some cause, and the most probable is the existence of different substances in these leaves. . . .

"W. Bird Herapath."

The foregoing conveys, however, but a very inadequate idea of the labour which Dr. Herapath had devoted to the subject. He had, it appears, analyzed optically upwards of 250 solutions; and in his rough MSS. he enumerates no less than fifty-four plants in the Fourth (or three-barred) Group. This list is appended, as it may be of service to future investigators; but it is obvious that we have now no means of knowing whether each individual of the series had been as fully worked out and verified as those given in the lithographed chart.

Laurestinus, Cucumber, Bay, Aconite, Œnothera biennis, Willow, St. John's Wort, Red Rose, Everlasting Oak, Scrophularia nodosa, Oak, Foreign Oak, Edible Chestnut, Horse-chestnut, Red Horse-chestnut, Larch, Maple, Alder, Lime, Birch, Walnut (leaves), *Ficus, Buckthorn, Nut, Holly, Red Bark* leaves (ethereal), *Red May, Wild Service Tree, Laurel, Cherry-laurel, Virginian Creeper, Wild Raspberry, Radish, Horseradish, Rhubarb, Dock, Secale, Beet-root, Blackberry* (old), *Iris, Red Lily, Lily of the Valley, Fern, Senecio Jacobea, Gallium album, Purple Sow-thistle, Periwinkle, Willow Herb, Cicuta virosa, Malva Moschata, Lamium Purpureum, Solanum Dulcamara, Wild Sage, Stork's-bill.*

II.—*Floscularia coronetta, a new Species; with Observations on some Points in the Economy of the Genus.*

By Charles Cubitt, Assoc. Inst. C.E., F.R.M.S.

Plates XXIV. and XXV.

My attention has long been directed towards an investigation of the mechanical actions of the vibratile cilia in the *Rotifera*, having failed on all occasions to recognize in what I observed, the effects that should properly result from the actions described by others. For instance, in Melicerta, Mr. Gosse writes* that "The ciliary vortices produced by the waves of the coronal disc pass together through the upper sinus, and are hurled in one stream along the

* 'Phil. Trans.,' 1856.

centre of the face, nearly to the projecting chin." And again,* "The particles are hurled round the margin of the disc until they pass off in front through the great sinus between the larger petals. . . . We see them swiftly glide along the facial surface, following the irregularities of outline with beautiful precision;" while my observations, on the contrary, show that the *marginal* cilia do not hurl the particles round the margin of the disc, but that they *apparently* make a continuous procession in one and the same direction around all the four petals; and the few particles that do follow the irregularities of the outline approach the sinus from *opposite* directions, on the one side of the animal in the same, and on the other side in the opposite direction to the procession of the marginal cilia, which could not happen if their passage were due to the direct action of such cilia; in fact, every particle that passes through the sinus is, during that passage, wholly unappropriated by the animal.

The true actions and functions of these and the accessory cilia about the trochal disc in effecting the prehension, selection, and appropriation of the particles respectively required for alimentary and architectural purposes is very distinct, and I hope at no distant period to arrange the deductions from these observations in a presentable form. With this end in view I have been led to a consideration of somewhat similar points of unconformity in the genera *Stephanoceros* and *Floscularia*, these animals having been in some cases referred to as occupying the anomalous position of *Rotifers without rotary organs*, though entitled to the position they occupy in the class by virtue of their inheritance of the same type of manducatory apparatus. Then again, the ciliated coronal disc, with its radiating setæ, has been frequently accepted and erroneously styled the *rotary organ*, in the face of visual evidence to the contrary; the setæ produce no continuous current, and beyond the sense of feeling and the function of retaining the captured prey within the funnel, they appear to possess only a capacity for twitching and jerking the involved particles from point to point, yet notwithstanding, it is evident there frequently exists a distinct and persistent vortex in their funnels, entirely independent of the action of the setæ, the necessary result of some motive power in the funnel, the true *rotary organ* in fact, which they certainly all possess; and in animals of the lowest form in their class, with the manducatory apparatus in a state of deep degradation, we must expect to find subordinate organs at a proportionately low point, and of the existence of such a low type of rotary organ I was able, by dint of careful observation, with superior appliances, to satisfy myself both as to the form and position in *Stephanoceros*, and subsequently much gratified to

* 'Pop. Sci. Rev.,' 1862.

find that a corresponding organ had previously been observed by Dr. Dobie, further described and illustrated by Dr. C. T. Hudson, in *F. campanulata*, in a paper communicated to the Bristol Microscopical Society in 1867, and to the courtesy of the honorary secretary of that society I am indebted for a copy of their Proceedings containing the same. Then, in the month of June last, when in quest of members of the family Flosculariadæ, a small gathering of the prolific water-moss *Fontinalis antipyretica*, from one of the small pools on Wimbledon Common, afforded me, amongst other species, a few specimens of the elegant *Floscularia* that forms the subject proper of this communication, and in describing this I trust I may, by frequent reference to the sketch and diagrams, be able to convey a lucid explanation of the character of the rotary organ which is very distinctly exhibited in this species.

In venturing to claim for it a place as a distinct species according to the present classification, I have been assisted in my selection of a title by a review of the examples afforded in the hitherto known species, in all of which the titles have been determined from the peculiar formation of the coronal disc, and on comparing this with the discs of the other species (Plate XXV., Figs. 2, 3, 4, and 6) I confidently rely on the conviction that the claim will be undisputed; and from the fact of having subsequently found, and continue still to find it inhabiting the *water ranunculus* on Wandsworth Common, widely separated from the first locality, there can be no question as to the species being permanent.

The first specimen that presented itself I mistook for the moment, on account of its size, its wrinkled footstalk, and its slender protruding lobes, for a young *Stephanoceros*, and on better acquaintance it certainly departs somewhat from the characters of the genus *Floscularia*, which are, as given by Oken,—Frontal lobes short, broad, knobbed, expanded; ciliary setæ very long, radiating crowded about the knobs; jaws each of two teeth. But inasmuch as the lobes in comparison with their width (the only gauge of length) are long, slender, and erect, it follows so far the characters of *Stephanoceros*, with which also there are further points of resemblance—first, in the fact that the gelatinous case is of the same viscid character, and not a hollow tube with thin walls, as described for *Floscularia*. It is not improbable however, or even unreasonable to suppose, in the face of accidental incidents that have offered themselves in support of that statement, that the tubes of all the species may also be of this same viscid composition. The following point can only be considered as a superficial resemblance, but at a first glance is most striking,—the dorsal lobe exhibits no *palpable* modification in outline, as is so noticeably distinguished in the other *Floscules* by the increased height and basal expansion both in *F. ornata* and *F. campanulata*, and by the addition thereto

of the specific horn in *F. cornuta* (Plate XXV., Figs. 2, 3, 4, and 5). There is, however, a physiological distinction with the dorsal lobe of this species which will be described in a subsequent paragraph.

An individual of this species when fully extended measures $\frac{1}{25}$th of an inch from the foot attachment to the knobs on the frontal lobes, beyond which the setæ can be definitely measured to a distance of $\frac{1}{90}$th of an inch, and at such times far excels in grace and elegance of figure any one of the others, the body curving easily up from the footstalk terminating frontally in a miniature coronet, and hence its specific title; but its refined symmetry is frequently diminished by being contracted to the extent of one-fourth of its length, with its body more swollen and rounded, and its footstalk drawn into numerous transverse wrinkles, characteristic of the family. These periods I notice are times of repletion.

Generally, the gelatinous case is scarcely to be detected, except from the accumulation of filamentous algæ and particles of floccose matter that are gathered and attached round about the posterior regions, giving it a much broader and shorter appearance than is ever seen in the tubes of other species, this extraneous matter reaching only a little beyond the footstalk of the expanded animal, which when withdrawn within this shelter is extremely difficult to find, from the general resemblance of the body and stalk to the surrounding aggregation of particles and filaments: unlike *F. campanulata*, it is extremely sensitive to external interruption, remaining long in retreat before venturing on its cautious and deliberate eversion; and to these particulars, added to that of its scarcity—occurring only once among a hundred others—may be attributed the fact of its having hitherto escaped observation.

The hyaline tube however, *is* present, projecting well up into the neck, far above the nest-like vegetable aggregation, studded throughout its mass with granules, which, by their passive repose in the midst of myriads of restless monads and *oscillatoriæ*, give the first and almost only intimation of the presence of their viscous matrix, except at certain periods after acts of evacuation, when it is seen to be more profusely pervaded with granules of the ejectamenta, particularly along the body of the inhabitant, which in retracting leaves most distinctly revealed the internal walls of the tube, conforming exactly to its outline, and rendered the more distinct by reason of a greater preponderance at this part of the voided infusorial particles in varying stages of disintegration, which clearly proves that the tube is in this species at all events of a viscid character, the same as that of *Stephanoceros*.

I will not presume to offer a description of the respiratory, nutritive, muscular, and reproductive systems which are physiologically common to the genus, and are so admirably described by Mr.

Gosse in his facile and forcible manner, further than to note some points that may differ therefrom in this species, or to suggest further inquiries in the economy of them all.

The currents of granular matter circulating between the body and the disc are here distinctly seen during the act of eversion issuing in an irregular mass from the second or labial diaphragm, principally along the dorsal aspect of the body, permeating the vessel round the neck, and coursing along the channels to the lobes, which they seem to inspire with sensitiveness; these channels from the collar to the funnel rim are arranged in pairs running down one from each angle at the bases of the lobes, except at the dorsal lobe, along which their course is in one central passage direct from the collar, the channels in pairs anastomosing at the diaphragm, descending thence to the posterior swelling of the body, where they are distinctly seen to merge into one tube, passing down to the foot, along the whole course of which are sparingly distributed isolated molecules of the circulating matter.

The frontal lobes are found somewhat of a dumb-bell figure, in transverse section (Plate XXV., Fig. 9), the thickened margins being continuous productions of the funnel rim, at their junction with which they exhibit internally the peculiarity called "Vacuola thickenings" (Plate XXV., Figs. 5, 6, 7, and 9), which, strictly speaking, is a misnomer, however convenient may be the acceptation of the term as expressing a "space filled with matter other than tissue," because a vacuum implies "a space unoccupied by matter;" they occur in the disc of this species as they do in many other Rotifers, and also in the prolongation of the body below the visceral cavity, points which are both effected by the animal's retraction in the folding of the disc and the contraction of the parietes of the body; and it is suggested for the consideration of observers that these "vacuola thickenings" are the effects of such foldings and contractions of the substance of the body in the respective positions in which they are seen. Take for instance the disc of *Lacinularia*, the vacuola thickenings are there shown in connection with radiating branches, and if a paper disc be made of a similar form, and drawn through a ring representing the neck, the puckerings or corrugations will assume something of the arrangement of the figure there shown.

The setæ are set, not only on the knobs from which they radiate in all directions, but are continued on each side of the lobe where they are very short, along the whole circumference of the disc, as in *F. campanulata*, increasing considerably in length in the spaces between the lobes, though not easily seen in a lateral view of the animal, and in the dorsal lobe the thickened rim is produced at its base into a rounded process at both angles (Plate XXV., Fig. 9 *b*), from each of which radiates a tuft of setæ approaching

in length those on the anterior knobs. This, therefore, is the distinctive modification of the dorsal lobe in this species; and when these distinctions are so persistent in every animal of this genus, it suggests the probability of an analogous distinction in the isolated species of the genus *Stephanoceros*. I have not hitherto been able to detect the slightest departure externally from the form of the other lobes, but, though not in support of the assumption, have been made aware of a perfect band of very small setæ running continuously round the interior of the funnel at the bases of the lobes, exercising the spasmodic action that distinguishes setæ from vibratile cilia.

The rotary organ of *F. coronetta*, as exemplifying the type of the genus, is situated internally at the cervical constriction of the body or neck, which is furnished with a collar extending horizontally round its entire circumference, divided diametrically in a lateral direction by a rounded process on each side (Plate XXV., Figs. 5, 6, 7 *c*); these processes are set with active vibratile cilia, springing from which and extending ventrally at a great angle of depression is a minutely ciliated belt (*d*) attached to the contractile membrane, in which it here creates a considerable vertical constriction (Fig. 6); and from the ciliated knobs (*c*) the dorsal division of the collar (*e*) anastomoses with the vascular vessel that descends from the dorsal lobe, where it forms a similar rounded process (*f*), which with the collar is unciliated, but is permeated with the granular substance that circulates through the disc, and certainly contributes important service in the acts of swallowing and ejecting.

The depression of the rotary organ is manifest in every species, for a lateral view exhibits, without exception, the labial diaphragm correspondingly depressed in the same direction.

The *ciliated* processes are capable, at the will of the animal, of either vibrating intermittently, producing a similar jerking effect to that of the setæ, or of working in regular sequence and creating a vortex, in which the particles are seen to revolve upwards through the rotary belt, and down along the dorsal lobe as shown by the arrows (Fig. 6). The animals appear to possess through the agency of the *simple* process the same faculty of discrimination in the selection of food that obtains in some, if not all, of the tube-building Rotifera, eminently so in Melicerta: thus the dorsal *unciliated* process is seen to approach, and, with the others, simultaneously to close upon the prey by means of a sudden contraction of the neck (Fig. 10), to retain the particle for an instant, and then either to reject or to swallow it, as the scrutiny may decide. In *F. campanulata* this action is very frequent; the dorsal lobe is there vertically bulged or corrugated inwards down to the *simple* process which exhibits the most delicate sensibility, reaching forward as if moving on a pivot at the funnel rim at the approach of the minutest monad.

It is assumed therefore that in these lower forms this member is the representative of the two ciliated organs in Melicerta, which manifest such rapid discrimination in its selection either of food or of building material.

In the act of swallowing, the mouth (g) is protruded upwards in close contact with these three processes (Fig. 10) to receive the particle and to pass it through the œsophagus (n) on to the manducatory apparatus; the particle is distinctly seen distending the œsophagus on its passage (Fig. 6 h), clearly proving that this cannot be a simple "waving veil," as described by Mr. Gosse; but from the fact of the mouth being a bulging, elongated orifice, merging into a tube beneath, the upper portion certainly presents something the appearance of a veil, and the tube necessarily assumes a waving motion with the muscular contractions of the labial diaphragm in its normal position, in consequence of the tube being longer than would be required if that position were permanent; but the œsophagus has to accommodate itself to the arbitrary positions that the diaphragm assumes, both in the acts of swallowing and ejecting particles, when the mouth, as before shown, is elevated, carrying with it and utilizing, so to speak, the "slack" of the tube that previously waved to and fro, but which is now rendered almost, if not perfectly straight.

The manducatory apparatus (it does not merit the term mastax) is situated very low in the stomach cavity, and is extremely small, the mallei only measuring each $\frac{1}{2000}$ of an inch in length; the stomach appears to be divided into more than one chamber, but the opacity of the viscera has hitherto prevented my determining definitely further than an intestine with a ciliated rectum leading to the cloaca, beneath which, and enclosed in the posterior swelling, is seen a clear transparent space (possibly a vacuole), but from its inconstancy it may be assumed to perform the actions of *diastole* and *systole*, the functions of a bladder, and its position near the cloaca, together with its occupation of a permanent swelling, would seem to corroborate the assumption.

The rapid process of retraction is very curious, and would be impossible to determine, except that the cautious and deliberate manner in which eversion is performed enables the observer to trace the *modus operandi.* The frontal lobes are simultaneously folded inwards and downwards at their bases, and abruptly returned at a short distance beyond, so that their anterior portions are retained in an erect position in the centre of the disc, which are then withdrawn within the funnel, leaving a *coma* of setæ protruding.

The ova, of which I have never seen more than two attached at one time, measure $\frac{1}{330}$th by $\frac{1}{500}$th of an inch in their respective elliptical diameters, the eye-spots in them very distinct, but less so,

though apparent, in the young animals $\frac{1}{70}$th of an inch long, with their discs developed: in the adult I have not, in this species, been able to resolve the eye; and this constant occurrence of the eye-spot, so distinct in the young and ova, and so difficult to resolve in the adult, when they have been seen in the lower forms, while they are always visible in the higher, suggests the solution that is here offered with much diffidence, and must be received as conjecture, requiring confirmation.

It is opposed to the plan of nature that any organized body should in any degree *degenerate** from the infant to the adult stage; if, therefore, the eye-spots are present in the young Rotifers, and apparently absent, or, at all events, difficult to resolve in the adult, the reasonable inference is, that the eye has *developed* and not *degraded*,—developed as a *simple* eye of a low type in the form of a lens, which, as a high refracting body, requires, of course, careful manipulation to determine with any class of illumination. In the lower forms it has been found that while any particle of colouring matter remains no appearance of a lens is visible.

Then, with regard to the higher forms, though the colouring matter is always present, it is changed perceptibly in character in the adult stage, leading to the conclusion that these possess a low form of *compound* eye; that the vanishing colouring matter of the simple eye is of a different character and composition to the permanent pigment of the compound; and that in both cases the animals are blind in infancy.

While, therefore, some of us are spending much time in resolving and discussing the markings on Diatomaceæ and Podura scales, I would invite the attention of observers to turn their attention to the investigation of some of these doubtful points in the economy of the higher *Infusoria*, a field of inquiry inexhaustible in interest.

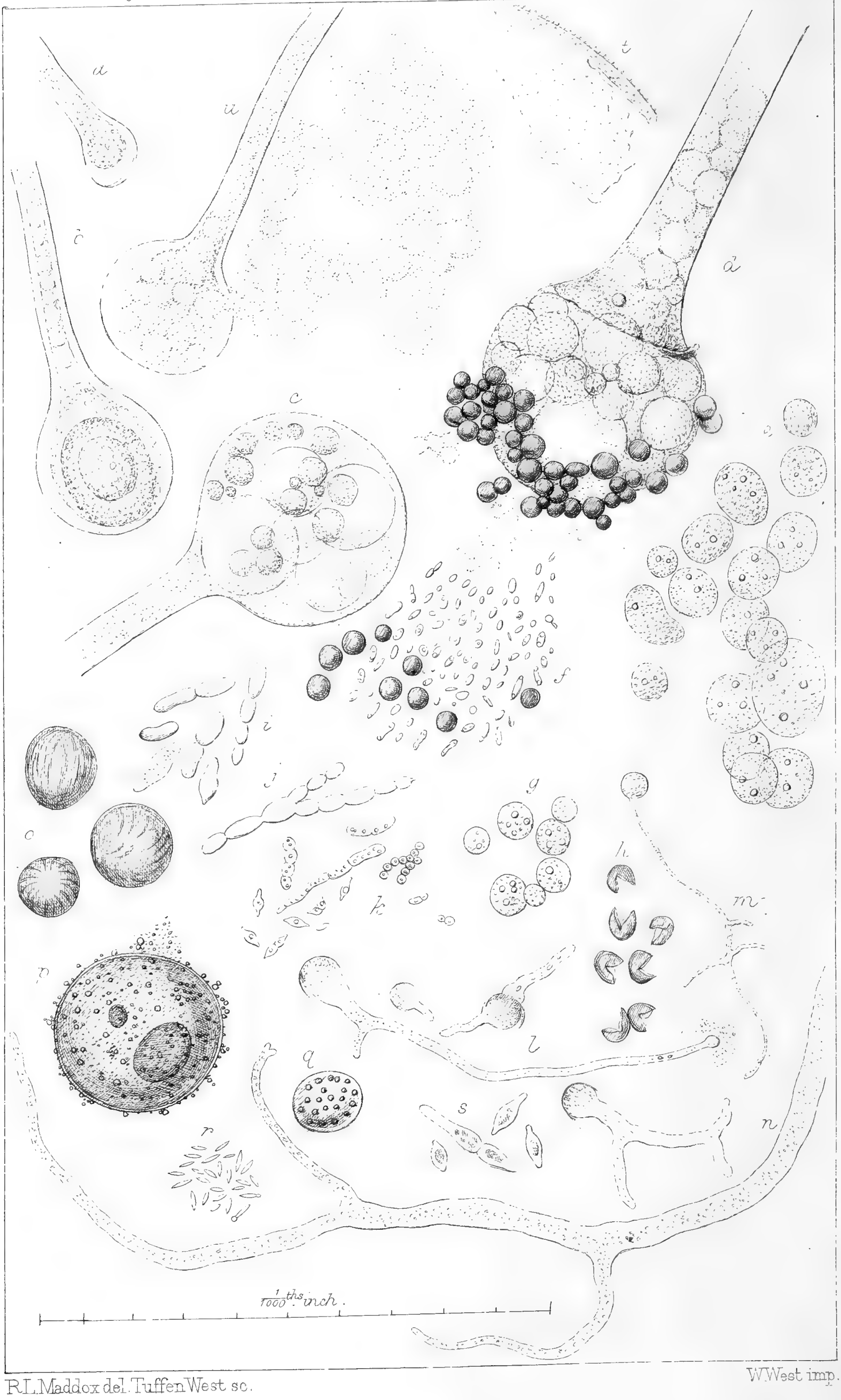
III.—*Observations on Mucor Mucedo.*

By R. L. Maddox, M.D.

The following remarks on Mucor Mucedo, occurring in a bruised ripe cherry, may at least add to the interest which invests these humble and prevalent structures, even if they do not exactly confirm the observations of others.

Among the Physomycetous Order of Fungi, we find *Antennariei* and *Mucorini*, the latter described in the Micrographic Dictionary as having a "Mycelium filamentous, vague, giving off erect simple or branched filaments terminating in vesicular cells

* We must object to this sweeping proposition, which is clearly the result of imperfect acquaintance with the facts of metamorphosis.—Ed. M. M. J.



R.L. Maddox del. Tuffen West sc.

W. West imp.

Mucor mucedo.

(peridioles) filled with minute spores, often with a central column in the interior." There are several described species of the genus *Mucorini* which is common on decaying fruits, &c., but it is doubtful whether some of these may not be the same plant under varying conditions of nutrition and light. In the above perfect plant, as it usually first attracts the observer, a number of little globular heads seated on erect non-septate filaments, varying in colour from whitish grey to grey or brown black, are seen springing from a filamentous network fixed by short rootlets in or on the substance on which the plant is seated, the colour of the filaments varying from pale yellowish to brown.

If with a fine pair of forceps we seize one of the erect filaments at the base, and place it on a glass slide, we shall probably find we have removed an entire plant of two to five or more stalks springing from the same base, terminating above in globose or oval heads, and below in several branched rootlets.

The globular heads very likely are of different growths, and if so, applying a little water to the edge of the cover, or some fluid, we may see (as at *a*), supported on a stalk, a slight enlargement in the young peridiole with a central portion or column occupying all or much of the interior, filled with a finely granular matter or

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EXPLANATION OF PLATE XXVI.

a. Commencing peridiole.
b. More advanced.
c. Still more advanced, containing hyaline cells.
d. A nearly ripe head, showing the spores set free by water, hyaline cells in the columella, and polygonal cells in the stalk; a little above the neck the attachment of the outer membrane, and at the top its hexagonal structure.
e. Large, somewhat denser cells than the spores, found on some of the ripe heads with ordinary spores.
f. Minute bacteroid bodies, and a few free spores.
g. Unripe spores.
h. Empty ripe spore cases, or capsules.
i. Oblong spores found near the neck.
j. Torula-like spores.
k. Minute bodies of *f*, growing, some very naviculoid in form, others filamentous, others round, free or attached.
l. Ordinary spores germinating, capsules burst but adherent.
m. Ill-conditioned spore.
n. Healthy young mycelium.
o. Ordinary ripe spores with corrugations × 750 diam.
p. A dense spore, with daughter-cells within of a brown colour, and numerous minute globules with dark outline both within and on its surface × 750 diam.
q. A cell with numerous nuclei? = to *g*.
r. Bacteroid or schizonematoid bodies from the same stock as *f*.
s. Same as *k* × 750 diam.
t. Outer spinous membrane of peridiole.
u. Young head discharging its grumous plasma from the contact of water × 120 diam.; all the other figures are magnified × 265 diam.

plasma (germinal matter), and continuous with that in the tubular stem. If a little more advanced, the head has enlarged, the contents are more differentiated, and a rather dense granular mass occupies the interior with a still denser mass towards its centre, this showing, in many cases, a pale cell within, or perhaps several, the plasma still communicating with the filament on which the head is expanding (*b*); on another filament we may find the pear-shaped head covered with closely applied dark spores, somewhat variable in size, those towards the neck often of an oblong or irregular shape (*i*), and the "core" with the stem darker in colour and denser in structure.

Various effects may have been noticed according to the particular head under examination. If sufficiently matured, on the approach of water, the outer membrane enlarges, suddenly bursts, and a grumous semi-cellular substance flows out (*u*) at the same time that the contents of the tube pass up into the head; when well-emptied, sundry cells come into view, seated close to the inner surface of the membrane or still deeper within; there is no septum visible between the head and filament. At a later period, as growth progresses, within are numerous rounded granular cells of nearly equal size as well as the hyaline cells, a globular head fills the centre, and the outer surface is seen freely covered with fine points (*t*); a little below the head may be noticed a very faint line which marks the point of attachment between the "core" and the outer membrane. I find no direct septum through the filament. Under compression the outer membrane shows hexagonal areolar structure, and this also is occasionally evident at a later period on the membrane of the "core" or column. When rather more advanced, well-marked spores are seen on the surface, which, by making their way towards the free surface, have ruptured the fine outer membrane, which may sometimes be found still retaining its hexagonal areas (*d*), but generally broken up entirely, the small points lying scattered about, whilst within the "core" everything, in well-nourished healthy plants, seems in activity. The hyaline cells are still seen, and if the specimen be ruptured these will sometimes float out with fine molecular matter, which fills the "core," and on being set free exhibits active molecular movements, though I have not been able to satisfy myself of any circulation proper of this molecular matter in the stem.* The globular spores adhere by contact for some time while the ripening takes place, and eventually fall away, leaving the central column collapsed but

* The circulation may be described as of two kinds: one general, the contents of the tubes of the mycelium, enclosing air-spores of varying shapes and sizes, sweeping somewhat rapidly and irregularly along the threads, even for considerable distances; the other, special, the small granules moving slowly along and round the fine threads, forming a loose net-work in the interior of many of the tubes; no mantle or other fluid was seen in conjunction with them.

adherent to the stalk, of a brown tint with often a ragged outline towards the neck. If one of the nearly ripe heads be viewed from beneath, the edges of what on a side view appeared as a more or less globular body, are seen to be folded in towards the expansion of the stem as if a solid body, as the closed hand, were pushed into a bladder partly filled with water, or somewhat like a raspberry.

What has taken place seems to be this:—The "core" and outer membrane are at first closely applied, but as growth proceeds germinal matter is formed between them, whilst in their expansion the junction remains near the neck, the space between the two membranes becomes gradually filled with a fine cellular structure, the remains of which are seen afterwards on both surfaces, and here the spores are elaborated, the central "core" keeping up the supply received through the rootlets, or perhaps even the surface of the mycelium. The contents in the "core" retain their connection with the stem, differentiation, in some of the heads at least, proceeds, and larger denser cells with several nuclei or daughter cells are formed, these when perfected being found with the ordinary spores; they are figured at (*e*), and cannot well be confounded with the others. Of *their* further history, as yet, I know nothing. Whether they may turn out to be an unknown sexual condition of the ordinary spore, or the phase of another form of plant suited for growth in media where the chemical constituents have been altered by the germination of the original plant or resting spores, is doubtful.

Whilst endeavouring to obtain a clue to this inquiry, some of the mycelium was taken from the ripe cherry with a few perfect plants or heads attached, and when under examination a drop of water was allowed to run under the cover, suddenly the whole field was flooded with minute bodies, enough even to confound a stanch Heterogenist or delight a Panspermist. I had not seen them hitherto. They were of various shapes, round, oval, oblong, with blunted ends, naviculoid, some united at their bases, and moved freely in the mingled fluid (*f*). With high magnifying powers, and under various methods of illumination, the cause of the movement was undiscernible.

The question naturally arose, Whence came those schizonematous (?) bodies,—did they belong to the mucor,—were they sexual representatives,—did they arise from the development of large spores or cells (*e*),—were they parts of another genus or species, &c., for I did not regard them as ordinary bacteria?

Experiments seemed the only method likely to determine this point, at least in part; they have hitherto failed in my hands, as will be seen, but are still under consideration.

Searching over the same slide, a few ruptured integuments of spores were seen (*h*), and with some of the somewhat oblong spores (*i*) from near the neck were noticed a few cells of a deli-

cate outline, in chains, as Torulæ (*j*). In all the examinations—and they were very numerous—excessively few of these chain-spores were seen, whilst the field was often suddenly flooded by the schizonematous (?) little bodies, (?) *bacteria*.

Examining the ordinary ripe spores with medium and high powers, the surface was noticed as (irregularly) finely corrugated. This is mentioned as any point elucidatory or diagnostic of one kind of spore compared with another, should such difference be found confirmatory, is of value when we approach the examination of atmospheric germs, and those of lichens of similar size and colour.

In the following experiments was sought, firstly, the germination of the spores from one of the ripe and unripe heads on a different fruit; hence one of each, so far as I could judge by close examination, was placed on a strawberry, on a white gooseberry, and on a red gooseberry, all being carefully wiped, the latter having had the skin *punctured* at one spot where the ripe spore was placed. These were set together in a glass vessel covered with a glass top, and put aside in a semi-dark place in my room (shelves with a sheet of newspaper fastened in front). In twenty-four hours, by hand-lens, no visible change; in forty-eight hours the ripe head had sent out a few filaments in the red gooseberry; the unripe head was removed with fine forceps; no change of the spores on the other fruits. Very little moisture had exuded from the puncture of the skin in the red gooseberry. In seventy-two hours the whole vessel was lined with a most charming crop of mucor-heads in all stages of growth, mostly adherent by their rootlets against the sides of the vessel; the other fruits were covered with the mycelium only, showing no germination of the spores which had been placed on them. They were carefully removed, with the mycelioid threads upon them; an examination was at once made of very many of the little plants, and the red gooseberry taken out. The part where it rested in the vessel was softened and somewhat decomposed, very moist, and covered with a thick byssoid matting. The juice beneath (about two large drops) was at once examined for the little schizonematous bodies; sure enough they were there, but very few in quantity compared with those from the mucor on the cherry. Some from the mycelium on the cherry was at once set in some juice from a fresh ripe red gooseberry on prepared slides with thin covers, one slide set in a glass vessel and placed in a dark cupboard, the other in the light, *i.e.* in a deep tin vessel with a glass cover, each having wet rag at the bottom. At the same time, for comparison, a slide containing yeast-cells from a fresh cask of beer, with small cells and numerous genuine *bacteria* and active molecules, was set in the cupboard, under the same conditions; twenty-four hours later the spores from mucor had become somewhat larger in both, and the movements less free in the slide placed in the dark.

In forty-eight hours the slide from the cupboard had become somewhat dry; a little fresh juice was added at the edge of the cover, and by gentle manipulation made to run under it. On the slide from the tin vessel the little bodies had grown every way: many had budded at the extremities and remained united; some had formed a short filament of two joints; others three, and contained either oil-globules or nuclei; very many had become decidedly naviculoid, others had kept their original contour and united in clains or little groups (*k*); the movements of the naviculoid, blunt and oval shaped bodies continued, but much less active; the others were motionless. On the fourth day (ninety-six hours), the bright spots in the centres of many had a vacuolated appearance, which, under 750 diameters, is figured at *s*. Were they degenerating? They are still under notice. Those in the slide in the dark cupboard had evidently faded, and at this period were smaller than when set aside. In appearance they resembled greatly the small faded yeast-cells in the slide from beer. I think it would have been almost impossible to distinguish them in this condition, though in the early stage there seemed considerable difference in very many, if not most of them. Hence to return to the examination of the little quantity of fluid in the glass vessel from the gooseberry: the second day it was watery, though still red; carefully examined, it furnished a few large rather dense spores or cells, with sometimes two or three brownish oval nuclei or secondary cells in the interior, mingled with many very minute dark granules and somewhat larger bright globules with a dark contour, numerous on the outside of the cell-wall, and not at all of the appearance of oil-globules produced by exudation (*p*), as seen at 750 diameters. Besides, a few of the mucor spores were noticed, which much resembled yeast-cells, or rather the cells from the unripe heads (*g*), but were of a dark colour (*q*). In ninety-six hours many little bodies, differing from the previous ones, though probably derived from them, were found in this fluid; they were generally sharp at each end, of a bright pale yellowish colour, and in mostly small and large groups, exhibiting no movement (*r*). They were set aside with fresh juice, and showed no change on the eighteenth day.

Secondly, experiments were made in reference to the germinal matter or protoplasm:—Two unripe heads, one rather less so than the other, were placed on a slide with fresh gooseberry juice and covered: the heads burst almost directly, and parts of the contents of the stem flowed out at the broken end;—the eighteenth day, having been kept in a moist atmosphere in the light, there was no material change in the viscid plasma of either the head or the stem, save in one of the former, dense oil-globules had exuded from the edges. At the same time, two rather riper heads were treated in the same

way. The granular spores, though partially separated from one head, are still adherent, and have enlarged; two of the most outside germinated on the sixth day; no further change on the eighteenth day. The whole of the spores in the riper head had germinated in twenty-four hours, and in forty-eight hours the appearance was that of a diminutive mop-head with tags reaching to the handle; the mycelium soon crept beyond the edge of a $\frac{5}{8}$-cover, and on the sixth day had numerous ripe heads at the edge of the thin covering-glass. The large threads were filled with fine granular matter, a little denser at the growing points and without ampullæ or enlargements (*n*).

The circulation of the granular contents was long watched in several of these threads' heads, and seen for the first time on the seventh day; the granules had the appearance of the swarming spores seen in the ends of *Closterium*, &c.; some of the threads were divided by septa at this period, others contained a loose, fine network of threads.

At this time the yeast-cells in the slide set aside had much degenerated; those which retained their usual condition had formed short chains, the central cell, much the largest, being filled with fine granules or nuclei; the jointed *bacteria* remained as at first, and the small granules showed no active molecular Brownonian movements; evidently the conditions were not favourable for development. Several other experiments were made.

In this article sundry points have been noticed: the growth of the spores outside the columella and within cellular areolæ between the outer and inner membrane; the outer membrane, formed originally with hexagonal areas, the inner by the membrane which constitutes the wall of the "core," and these united at one part of their course; communication of the germinal matter in the core with that in the stem and rootlets; its circulation in the mycelium; sundry markings or corrugations on the ordinary ripe spores; the appearance of larger cells in some heads, from the further development of the germinal matter in the "core;" the non-conversion of the grumous contents of unripe spores or heads into *bacteria*, or any other form of life, when placed in a medium in which the ripe spores readily germinated; the question opened as to the origin of certain free schizonematous or bacteroid bodies, their gradual development in parts, and of the larger cells in the *media* used for the regerminating experiments, &c.

In this paper all allusion to experiments on animal tissues or fluids has been expressly avoided.

Being fully aware of the doubts that may be raised in all similar experiments, by enclosing unsuspected floating spores or living germinal matter in such a state of division as to defy proof by the highest powers in the hands of microscopists; hence just such pre-

cautions were taken as seemed of real utility in a question so balanced. Having no theory to support, the general descriptive evidence—prefacing may be future experiments—is left to those who like to apply the missing "modes of motion." Unfortunately we, who are only at the threshold of inquiry, to suit our theories are apt to question somewhat dogmatically, plan rules, and set restrictions on the ways and means of Him who has been working for ages; hence the contradictions which so continually betray our ignorance, whether as regards the past, present, or future of the smallest living speck, or the complex organism of the most sentient and intelligent being. What was the first "mode of motion," —what the first atom capable of "evolution,"—of converting surrounding material to its growth,—of reproducing its like, &c.? Echo will reverberate round the world, chased by its hollow sound, an empty answer, while Time gathers generations of the wisest.

IV.—*On the Detection by the Microscope of Red and White Corpuscles in Blood-stains.* By JOSEPH G. RICHARDSON, M.D., Microscopist to the Pennsylvania Hospital.

SINCE the elaborate researches of Gulliver and Carl Schmidt, in regard to the exact variation of size among the blood corpuscles in different species of vertebrates have been laid before the profession, microscopic examination of blood-stains has assumed an importance in medical jurisprudence far greater than any or all the other methods as yet suggested for the discovery of crime in cases where such recognition depends upon the presence of blood. So characteristic, indeed, is the combination of red and white corpuscles in the circulating fluid that one might almost as well pretend to doubt the infinite probability that a countless procession of creatures, bearing every appearance of being men and women, was actually composed of members of the human family, as to dispute the fact that a drop of liquid exhibiting the normal corpuscles in their usual abundance, when examined with a suitable power of the microscope, did in reality consist of blood.

When, however, as most commonly occurs, the microscopist is called upon to determine the presence or absence of blood in a dried spot upon cloth or other material, and especially if the exigencies of the case demand a decision whether, if blood, it is that of a human being, the task often becomes extremely difficult, and has hitherto been abandoned as insurmountable by some authorities upon the subject; while others, more sanguine of general success as they

seem to be, yet fail to give the minute directions which would alone enable their readers to follow even at a distance in their footsteps.

Being recently called upon to investigate this subject, as connected with a criminal trial in one of the Eastern States, I was led to some extended researches upon the dried blood corpuscle, developing some of their characteristics which may prove useful to other microscopists engaged in similar studies, and contribute to extend the field of the instrument as an aid to medical jurisprudence.

As intimated above, several of the standard authorities, among whom may be cited Taylor, of London, Briand, of Paris, and Wharton and Stillé, of this city (Philadelphia ?), in their respective works on 'Medical Jurisprudence,' assert that, with proper care and practice, one can generally distinguish the characters of corpuscles in dried blood-stains; as, for instance, the latter of these gentlemen informs us, on p. 678 of the edition of 1860, that—"When the tissue has been well soaked (in solution of sulphate of soda) the stains may be carefully detached with a scalpel and the liquid placed upon a glass slide, and immediately covered with another one. . . . A portion of the globules will be found free; while others will be attached to the fibres of the stuff, but they will preserve their natural colour, volume, and more or less their shape also, to such an extent, however, as to be readily recognized."

But, on the other hand, we find that many microscopists who have specially investigated the subject, entertain a different opinion as to the facility with which the problem can be solved; thus, for example, Dr. Andrew Fleming concludes his able monograph upon blood-stains, republished from the columns of the 'American Journal of Medical Science' for January, 1859, with the acknowledgment:—"From the experiments which I have made during a period of several years with blood belonging to different animals, when dried for a length of time and moistened again, I am forced to admit that great difficulty arises in attempting to fix its origin by the comparative size of the corpuscles; and again, that the blood of ovipara, when kept for several weeks, does not present the peculiar elliptical corpuscles found in fresh blood in a form sufficiently perfect to justify me in declaring positively whence it proceeds."

Dr. B. W. Richardson, of London, in his work on the 'Coagulation of the Blood,' p. 459, observes:—"Much has been said and written about the differential diagnosis of the blood of man and of other mammalia. For my own part, I am free to say that if specimens of blood from man, from the ox, sheep, pig, guinea-pig, dog, cat, or rabbit were placed before me, I should be utterly unable to say with precision, from any examination which I could institute, chemical or microscopical, from which of these animals the specimens were derived."

Professor J. Wyman, of Harvard College, one of our most skil-

ful American microscopists, gives, as the result of his experiments upon dried blood:*—"If a drop of blood be rubbed on a piece of glass, as by drawing a bloody finger across it so that the disks are deposited in a *single layer*, and then allowed to dry, they are readily recognized even in the dried state; but when allowed to dry in masses, I have failed to determine their presence. The lymph globules, on the contrary, may be softened out after they have been dried for months, and their characteristic marks readily obtained."

And Prof. Virchow, of Berlin, observes:†—"In regard to the diagnosis by this method (difference in size of the blood globules in mammalia), I can only endorse the unfavourable opinion of Brücke, and I do not believe that any microscopist will hold himself justified in putting in question a man's life on the uncertain calculation of a blood corpuscle's ratio of contraction by drying."

One of the primary steps in entering upon an investigation of blood-stains is the selection of a proper menstruum for moistening the dried clot, and here at the outset we meet with a great discrepancy of opinion; by some authorities pure water, which certainly has the advantage of far greater convenience in its employment, is highly recommended, whilst others who prefer saline solutions, fixed or volatile oils, &c., condemn the use of water as utterly destructive to the red corpuscles; thus, M. Ch. Robin, of Paris, in a translation of one of his articles on the subject in the 'New Orleans Medical News,' December, 1857, is credited with the following statement:—"By scraping the small crust (of a blood-stain), as seen under a simple magnifying glass, and receiving it either in the shape of dust or small fragments, under the ordinary glass object-carrier, we found that water discoloured (decolourized?) the spots or the substance taken up by scraping, that the latter takes a greyish hue and swells up a little; the water, on the other hand, becomes slightly red, takes up the colouring matter of the red globules of blood, *dissolves the colourless elements*, and leaves after this action no visible particles behind, such as nucleus or granulations." Prof. Robin declares the residuary grey mass to be "composed entirely of fibrin."

This opinion in regard to the action of water on the red discs seems to be one widely accepted at present, for we find Prof. Austin Flint, jun., of New York, observes, on p. 116 of the first volume of 'The Physiology of Man,' published in 1866:—"If pure water be added to a specimen of blood under the microscope, the corpuscles will first swell up, become spherical, and are finally lost to view by solution;" and Prof. Lionel Beale teaches, on p. 169 of the 'Microscope in Practical Medicine,' that the red corpuscles are simply "masses of soft viscid matter, perhaps of the consistence of

* Bemi's 'Report of the Webster Case,' p. 91.

† Virchow's 'Archiv.,' band. xii., s. 336.

treacle, composed of hæmato-crystallin," and while admitting that the outer part of each mass may be of firmer consistence than the interior, denies that in mammalia generally they possess a true cell-wall, so that, if his doctrine be correct, the chance of detecting any isolated red corpuscles in a mass of blood clot, howsoever moistened, seems almost as hopeless as the search after individual rain-drops in a cake of melting ice.

In the progress of some researches upon the distension of the white blood-cells when acted upon by water,* I have often incidentally noticed that many of the red corpuscles become, after a time, so transparent and colourless by the solution and abstraction of their "hæmato-crystallin," that they are quite invisible under a power of 400 diameters, and appear to be in reality dissolved as stated by Prof. Wyman, M. Ch. Robin, and other authorities; yet when closely scrutinized under a $\frac{1}{25}$ immersion objective, their faint transparent outlines can still be detected, thus confirming Prof. Beale's assertion † that "with the highest powers not only do we meet with extremely minute corpuscles, but many of them are so very transparent that they could not be seen at all under a low power. Extremely transparent bodies are demonstrated under high powers, which would certainly be passed over by those in ordinary use."

This observation appeared to have such an important bearing upon the subject of my present paper that I entered upon its special investigation, which I propose briefly to detail, promising that while the results seem to prove a very marked difference in density, if not in constitution, between the external and internal portions of the blood discs, I do not consider the data here collected sufficient for controverting the opinions of those experienced histologists who deny to the red corpuscle a proper cell-wall.

Expt. 1.—Five drops of blood drawn with a cataract needle from the tip of the finger was stirred with half a fluid-ounce of river-water in a conical wine-glass, which was carefully closed against the entrance of extraneous matters and set aside. Twenty-four hours after a scanty sediment, whitish in colour, was visible in the bottom of the vessel, and a small portion of this deposit examined under the $\frac{1}{25}$, showed that it was chiefly composed of red blood discs, exhibiting no appearance of rupture, globular in form, quite colourless, and so transparent that very close attention was necessary for their detection. Similar results were obtained at the end of forty-eight hours, but at the end of seventy-two hours many of these globules were obscured by the formation of Vibriones and Bacteria, which were developing with great rapidity.

Expt. 2.—A thin film of human blood was spread out upon a slide, allowed to dry, covered with thin glass, and then adjusted under the $\frac{1}{25}$; after finding a suitable field which contained a white

* 'Pennyslvania Hospital Reports,' 1869. † *Op. cit.*, p. 170.

blood corpuscle surrounded by rouleaux of red ones, water was introduced at the edge of the cover by means of a thread from the reservoir. As the wave of fluid, deeply tinged with colouring matter it had dissolved, crossed the field of the microscope, the corpuscles were, for a few moments, obscured, but in a short time the white cell reappeared, and soon after the very faint but unmistakable outlines of the red discs again became visible. This experiment was varied by irrigating some fields exhibiting isolated red corpuscles, and others where by crowding together they had formed an apparently homogeneous clot, in every case with the same result where a high power was employed; with the $\frac{1}{4}$-inch objective, however, I was unable to satisfy myself of the existence of these eviscerated discs. By careful measurement with the cobweb micrometer, the white corpuscles were found to first diminish slightly on contact with water, and afterwards to expand to rather more than their original diameter, while the red discs appeared to suffer a permanent decrease from about $\frac{1}{3050}$ to $\frac{1}{3800}$ of an inch across.

Expt. 3.—Some minute fragments of dried blood from a stain made upon a piece of muslin about three months before were placed upon a slide and adjusted on the stage of the microscope; after finding a suitable portion of clot with a thin bevelled edge, water was introduced at the margin of the cover and allowed to flow very slowly towards the chosen fragment; when this was reached by the wave of fluid a remarkable appearance of boiling up from its centre was presented for a few moments, and then as the tinged liquid was replaced by pure water an aggregation of compressed corpuscles, very faint and colourless, but yet of unquestionable distinctness, became apparent; a few straight interlaced filaments of fibrin were visible, and at intervals the granular spherical lymph globules occurred among the other elements; these white cells frequently became detached, and floated freely around the edges of the clot, where, as well as whilst still embedded, they were so much more readily recognized with a low power that I suspect they have often been mistaken for the red discs. By introducing at the margin of the cover, a minute portion of iodine solution,* the outlines of the decolourized corpuscles are rendered far more obvious, and can often be distinguished even by inexperienced observers.

In a similar manner the blood of an ox, sheep, pig, chicken, turkey, and canary bird, most of them dried in a thin film upon a slide, and all dried in a mass upon paper or muslin, were carefully examined, and little difficulty found in distinctly perceiving that the colourless stroma with its "straight or slightly waving filaments, sometimes more fibrous, sometimes more wrinkled and homogeneous,"† so long mistaken under lower powers for a mass of fibrin, was actually an aggregation of decolourized red corpuscles,

* Beale, 'How to Work with the Microscope,' p. 207. † Virchow, *loc. cit.*

with rare filaments of fibrin, and white blood cells imbedded in it. It is true that the older microscopists who rarely obtained first-rate definition with their lenses magnifying much beyond 500 diameters, were probably wise in recommending that none but the most expert should attempt a decision between the blood of various mammalia, even when fresh, for the difference between an apparent magnitude of $\frac{1}{10}$ and $\frac{1}{12}$ of an inch may well be counted too minute to lightly determine a question often so momentous; but as during the last three or four years opticians have furnished immersion lenses of $\frac{1}{25}$ and $\frac{1}{50}$ of inch focal length, which with the highest eye-piece give an amplification of about 2500 and 5000 diameters respectively, thus rendering, with the former, the apparent size of a red disk from fresh human blood five-sevenths of an inch, while that of a corpuscle from ox blood is but half an inch across, and consequently little more than half the area as seen upon the stage, it seems as if any careful observer might now, with the aid of such objectives, be qualified to pronounce a positive opinion.

It has been plausibly objected, however, as by Prof. Virchow in the extract above quoted, that since the diagnosis of the different species of mammalian blood depends solely upon the relative size of the red disks, variation in the rapidity of desiccation may sometimes cause dried corpuscles to so deviate from the ordinary degree of contraction during that process as to lead the microscopist, who relies upon the characteristic of magnitude only, into serious or fatal error. In order to test the truth of this hypothesis, drops of blood from the finger, deposited upon pieces of muslin, were dried under various circumstances; fragments of the stain removed by scraping were then moistened with pure water, and from each variety of desiccated spot, ten corpuscles selected without regard to size, as among those which had best retained their normal circular outline, were carefully measured with the micrometer. Upon comparing the averages of these, as appended below, it will be seen that the difference in the mean diameters does not amount to $\frac{1}{140000}$ of an inch; in no instance was a circular red disk observed to exhibit such an approximation in magnitude to those of ox blood, as could, by any possibility, render its different origin a matter of doubt.

TABLE.

Ten blood corpuscles moistened with water from a clot on muslin which had been dried:—

	Diameters. Max.	Min.	Mean.
In the open air at ordinary temperature	$\frac{1}{3346}$	$\frac{1}{3625}$	$\frac{1}{3480}$
Before a hot fire	$\frac{1}{3346}$	$\frac{1}{3783}$	$\frac{1}{3564}$
In the afternoon sunshine	$\frac{1}{3346}$	$\frac{1}{3783}$	$\frac{1}{3536}$
In a damp, dark closet	$\frac{1}{3346}$	$\frac{1}{3700}$	$\frac{1}{3552}$

These various experiments appearing to indicate the absence of any tendency in the red blood disk to undergo expansion, I was led

to make the following calculation, which tends to show that the outer portion of the corpuscles (whether it be merely condensed viscid material, or a true cell-wall composed of membrane distinct in composition from hæmato-crystallin) is of an inelastic character. Ten red globules of freshly-drawn human blood magnified almost 1800 times were measured with the micrometer while standing on their edges, both in length (as so placed) and in thickness, their mean diameter being found equal to $\frac{1}{3346}$ and their mean of greatest thickness $\frac{1}{13385}$ of an inch. From these data, estimating the total surface of the globule as approximatively equivalent to ninety-six one hundred and sixty-firsts of a ring ·00029886 in outside diameter, and ·00007478 of an inch thick, plus double the superficies of a segment with a versed sine of ·00003739 cut from a sphere having ·00017718 radius, I calculated the area of the hypothetical cell-wall to be ·00000017932 of a square inch; by further computation, it was found that this amount of membrane would cover a globe ·00023891 of an inch in diameter, which number so nearly coincides with that expressing the diameter of the red disk, when rendered spherical by the action of pure water, *viz.* ·00023332 ($\frac{1}{4286}$) of an inch, that I think we may fairly conclude that, although the shape of the corpuscle is thus altered, its parietes undergo no real dilatation in the process; further, the corrugated appearance assumed by the corpuscle when any portion of its internal constituent is removed by exosmosis affords some evidence that, however much the cavity is decreased, its limiting membrane suffers no actual diminution in superficial area.

Although it must be admitted that the blood corpuscles of a few mammals approach so nearly in size to those of man as to render their distinction doubtful, yet for the practical testing of blood-stains in criminal trials we will rarely find that such a decision is necessary, since, as a rule, justice only requires that a positive diagnosis shall be made between human blood and that of animals which are commonly slaughtered for food, such as the ox, the sheep, the pig, or of birds, as for example, chickens, ducks, &c., in regard to all of which I believe when the disks have not undergone disintegration, a first-rate $\frac{1}{25}$ inch objective will enable us to determine easily and beyond all question.

I would suggest to any one about undertaking such an investigation, that he first accustom himself to the appearance of decolourized blood corpuscles, and at the same time test the power of his instrument by repeating Experiment 3rd, as detailed above, on a fragment of blood clot recently desiccated upon paper or glass. Experience has shown that dried stains upon hard, smooth surfaces, such as buttons, studs, &c., most readily exhibit the corpuscles; next to these in case of detection, are stains upon paper collars or cuffs, and upon highly glazed linen; then those upon unstarched

muslin or linen; and lastly, those upon cloth and other woollen fabrics. In order to be forearmed against the objections of ingenious counsel, he should in murder cases, wherever practicable, be provided with spots made before witnesses, with fresh blood from the corpse upon different unstained portions of the identical articles of the supposed murderer's clothing, and also with specimens of the blood dried in a thin film upon glass slides, for the purpose of disproving any hypothesis of leucocythemia, or other blood diseases, which might alter the normal character or relative proportion of the blood elements.

In examining the moistened clot, great care must be taken to avoid any movement of cover upon the slide, which, when it occurs, often rolls the interposed disk into an apparently homogeneous mass; and it is advisable to keep up a current of fresh water, at least, until all tinge of colour is removed from the clot, otherwise none but the granular lymph corpuscles can be visible. Should any doubt remain as to the identity of these bodies, it can be set at rest by treating them with acetic acid or solution of aniline, as noted in a paper on the "Detection of Undiluted from those of Diluted Blood-stains," in the American 'Med. and Surg. Reporter,' Jan. 9,1869. In order to complete a chain of evidence it is probable that the decolourized corpuscles in a fragment of clot after being rendered more distinct by iodine, as above mentioned, might often be demonstrated, if required in court, to intelligent jurymen, especially where as surveyors, watchmakers, or engravers, the jurors were not unaccustomed to the use of lenses.

It may not be out of place to subjoin a comparison of the relative delicacy of the different processes recommended by medical jurists for the discovery of blood-stains.

By the intricate and tedious method of M. Taddeî,* "A piece of linen or cotton, which hardly contained 28 to 30 centigrammes (between four and five troy grains) of dried blood furnished enough for the determination of its nature."

A plan suggested by Dr. F. Runge, in which the iron of the blood was tested for by ferrocyanide of potassium, is spoken of by Dr. Fleming as being so very delicate, that a single drop of blood sufficed for complete detection.

By spectrum analysis lately vaunted as successful when ordinary microscopic examination fails, it is claimed that $\frac{1}{1000}$th of a grain of dried blood may be recognized, but no clue is thus afforded to the animal from whence the vital fluid is derived.

Through the courtesy of Dr. Linderman, Director, and Mr. J. R. Eckfelt, Chief Assayer of the United States Mint, I was enabled to estimate the delicacy of the microscopic test for blood, as follows:—Upon a square of waxed paper determined by Mr. Eckfelt

* Fabre, 'Bibliothèque du Médecin Praticien,' tom. xv. p. 264, Paris, 1851.

on the accurate balance used for the National Assays, to weigh exactly 48 milligrammes, I made twenty dots of fresh blood from my finger, which, when dry, added ·4 of a milligramme to the original weight, and consequently were each on an average equivalent to about ·02 of a milligramme, or $\frac{1}{3200}$ of a troy grain nearly. The fourth part of one of these spots, weighing of course in round numbers $\frac{1}{12000}$ of a grain, was detached with the point of a cataract needle, and when moistened under the $\frac{1}{25}$ showed many hundred well-defined red blood corpuscles; ten circular ones among these measured with the micrometer averaged $\frac{1}{3494}$th of an inch in diameter, and could therefore, by this criterion of superior size alone, be diagnosticated from the corpuscles of an ox, sheep, or pig, with the same feeling of certainty with which any surgeon could testify that a perforation of the skull only half an inch across could not possibly have been made by a bullet measuring an inch in diameter.—*Paper read before the Microscopical Section of the Academy of Natural Sciences, Philadelphia, and communicated to the 'Monthly Microscopical Journal' by the author.*

V.—*On the Staining of Microscopical Preparations.*

By Dr. W. R. M'Nab.

1. *Staining with Acetate of Mauvine.*

A. This can be used with very good effect in staining thin sections of wood. If these are preserved in Canada balsam they seem to be permanently stained, as a few specimens put up in January, 1866, are now quite as brightly coloured as they were at first. By means of the colouring the high powers of the microscope can be used, bringing out points of structure not easily demonstrated without being so treated. Sections (transverse) of coniferous woods show beautifully the structure of the punctated tissue, as well as the junctions of the cell-walls and the thickening layers of ligneous matter.

B. Sections of the young stems of ivy were last year (February, 1868) successfully stained with acetate of mauvine and glycerine.* Since then most of the specimens have faded. The contents of the cells have lost colour entirely, but the cuticular layer of the epidermis retains its colour, as well as the young ligneous cells. In a specimen now before us, the pith and the enclosed cell-contents are now colourless, but the zone of cells in which a deposit of ligneous matter has been formed are brightly coloured. The very small

* See 'Botanical Society Transactions.'

cambium cells bounding this layer are quite colourless. In the outer layer of cambium the cells become large, more like the bark cells, and here and there a few bundles of thickened cells can be seen, brightly coloured like the others. These, I suppose, are *bast cells*. A few of the laticiferous canals, described last year in 'Botanical Society Transactions,' are lying close to these small patches of bast cells, but far more frequently they lie close to the small cambium cells. The layer of cellular tissue, external to the bast cells, is not coloured, and their thin walls contrast strongly with the greatly thickened cell-walls of the epidermal cells, on which the mauvine does not seem to exert any influence. The cuticle is well marked as a bright purple external layer, contrasting strongly with the colourless thickened cells on which it rests.

If any reliance is to be placed in the results obtained by staining specimens with mauvine, there is one very important point I wish to mention. Schacht * states that the so-called intercellular substance, joining the walls of contiguous cells together, forms on the free surface of the cells what is known as the cuticle. By some the existence of this intercellular substance is denied; and by careful examination of many specimens now before me, I can find no trace of any such material. The cuticle is brightly coloured, and if the same material existed as intercellular substance between the cells, a coloured layer should be seen between each of these cells, but none can be seen. If, then, the test of colour can be relied on, either intercellular substance does not exist, or else its composition is essentially different from that of cuticle.

2. *Staining with Beale's Carmine Solution.*

When small portions of vegetable tissue are soaked in the carmine solution, only those cells containing protoplasm appear stained. The nuclei and the granules in the protoplasm seem alone to be affected. The depth of colouring depends, then, on the number of granules in the protoplasm and the size of the nucleus.

A. *Experiments in* Phalaris canariensis.—The rootlets of germinating seedlings of *Phalaris canariensis* were placed in a solution of carmine. When examined about twelve hours afterwards, the extremities of the rootlets were found to be very deeply coloured, while a faint tinge was visible along the other parts of the rootlet. Under the microscope the structure of the growing point of the root was beautifully seen. First a series of loose cells are seen at the extremity, continuing a short distance above the growing point. A very few of the most internal cells seem to be slightly coloured, the external ones being quite colourless. This mass of cells forms a regular sheath-like cap to the growing part of the root, very similar to the highly developed pileorhiza of Lemna. A well-

* 'Grund. der Anat. und Phys. der Gewächse,' p. 29.

marked line of separation can be seen marking the boundary of the growing point, the cells being deeply coloured for a short distance. The cells are densely filled with granular protoplasm, and each contains a very large nucleus. A little higher up the colouring gets very faint, and at last is confined to the interior of the rootlet, where a few nuclei are seen closely surrounding the spiral vessels. The growing point of a root of the Phalaris, when treated with carmine, shows—1st. A number of large loose cells at the point, extending like a pileorhiza, a short distance from the extremity; 2nd. The internal cells of this sheath are coloured, and therefore contain active protoplasm; 3rd. The growing point of the root is very deeply coloured, the protoplasm is densely granular, and contains a large nucleus; 4th. A very short distance above the growing part the cells are only marked by an occasional nucleus; and, lastly, the nuclei are only found close to the spiral vessels.

B. *Experiments with* Sinapis alba (*White Mustard*)—*Series* 1.—These were begun in February, 1868, and consisted in germinating white mustard both in water and in soil, and then examining the structure after staining with carmine. During the first stages of germination of the seeds, germinated both in soil and in water, no trace of staining could be found, and it was not till the radicle had attained some size that the point of the root became stained with the carmine. If we can depend on such tests, we must conclude that the germination of the white mustard is not dependent on the formation of *new cells,* but merely on the growth and enlargement of the pre-existing cells. Whenever growth by the formation of new cells had taken place these cells could be rendered distinctly visible by the action of carmine, the parts above this remaining white, although submitted to the action of carmine under precisely the same conditions.

Series 2.—A much more extensive series of experiments was tried in December, 1868, by growing white mustard for a short time in carmine solution. After the plants were about two inches in height carmine was added, and they continued to grow for several days after. The youngest stages of development failed to furnish stained specimens, and it was only after a few days that the young radicles could be stained. The structure of the root is more complex than that seen in the *Phalaris canariensis,* but agreed in every essential point. The loose cells were seen at the tip, the growing point densely coloured, the colouring becoming less and less till it was no longer visible. The protoplasm near the growing point is densely granular, and the nuclei very large, filling up from one-fourth to one-third of the whole cell.

Transverse sections of the young root, above the growing point, showed the arrangement of the cells very clearly. In the centre is a mass of small thickened cells, containing protoplasm and nuclei

in many cases. Immediately outside this are three layers of large cells with protoplasm and large nuclei. Surrounding this layer is a single series of small cells placed very close together, containing a densely granular protoplasm, and very large, often two, nuclei, probably a cambium layer. External to this is a layer of epidermal cells, not apparently thickened, the whole being enclosed by what appears to be a thickened cuticle. Parts of the young radicle are covered with hairs. These could be very clearly seen, and their mode of formation observed. I cannot detect any thickened cuticle at those parts where the hairs are developing. The hairs are direct prolongations of the epidermal cells, and in general the contents and nucleus can be seen to have been carried forward, and occupying the centre of the hair. The sections I have now before me, showing the hairs, are much farther from the growing point than that described above as having a thickened cuticle, but no cuticle is visible. The hairs elongate very much, without dividing; the nucleus in most was wanting, although the granular contents remained. Here and there large spaces filled with cell-sap were seen, and in one instance the contents of one of these long cells were seen oscillating backwards and forwards for some time. The use of the staining process does not seem to be attended with any great difficulty, and, I have no doubt, important results may be obtained by careful study of its action on germinating plants.—*Transactions of the Botanical Society of Edinburgh: paper forwarded by the author.*

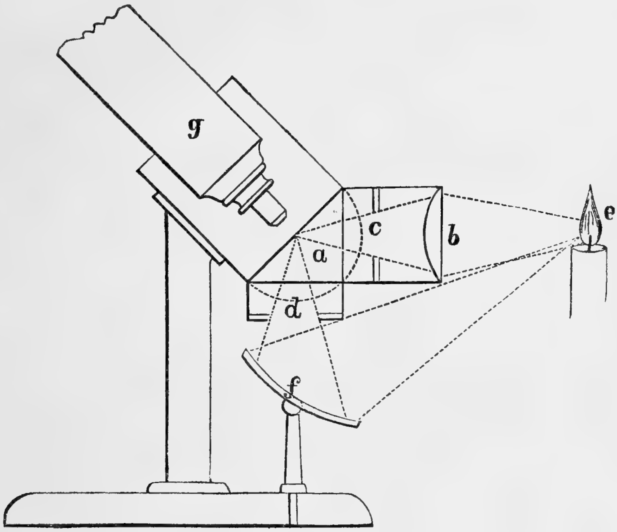
VI.—*Some Further Remarks on an Illumination for Verifying the Structure of Diatoms and other Minute Objects.*

By F. H. Wenham.

Additional observations with the principle of illumination, suggested in this Journal for July last, No. VII., have shown that it displays many objects with a degree of truth not obtainable by any other means; for it must be borne in mind that it involves this singular peculiarity, *viz.* the whole of the light is conveyed into the interior of the object itself, which appears self-luminous in a jet-black field. In all other methods with which we are acquainted, light is either directly transmitted, or thrown on the surface, the glare from which in many instances prevents the interior structure from being seen.

The cut is an arrangement illustrative of this principle of illumination. *a* is a right-angled prism, or which may be a hemispherical lens, as shown by the dotted lines; *b* is a condensing-lens, behind which, and also below the prism, are stops *c* and *d*; *e* is

the light which enters direct into the vertical face of the prism, and is reflected upwards through the under-side by means of the mirror *f*. The diagonal face of the prism is surmounted by a



dark box, through which is introduced the microscope body, with object-glass, *g*. The side of this box has a sliding shutter opening level with the face of the prism, for the introduction of slides and detached objects.

The two lights simultaneously transmitted through the rectangular faces of the prism will both be totally reflected from the diagonal surface, and if this is clean not a trace of light will be seen in the dark chamber. A fragment of thin white paper laid on the prism will be quite invisible under the microscope. If now, with a needle-point, we touch the paper with a minute drop of water, so as to bring a spot in aqueous contact with the prism, this will destroy total reflexion at the part, which will appear brilliantly luminous.

If a water-snail, aquatic larva, or caterpillar is placed on the prism with a drop of water, the whole of the interior anatomy is distinctly seen, as the light enters the part only of the object in contact with the glass, and is diffused throughout the body. When objects mounted on ordinary microscope slides are to be viewed, some water must be placed on the back of the prism; and if the object is a moving one, it may be laid on a blank slide, and this traversed over the prism with water between.

Though this arrangement displays large transparent objects,

magnificently, yet for the ordinary class the inexpensive plan described in No. VII. may be employed, consisting of the truncated lens, therein shown, cemented to an ordinary glass slide with Canada balsam. This must be used in conjunction with the parabolic condenser, and the rays rendered parallel by the bull's-eye. Instead of water, the top of the slide may be covered with a film of glycerine, which will not evaporate; of course this does not influence the total reflexion which now takes place from the upper surface of the glycerine. If now filaments of plants, animalcules, or hairs of animals be laid on the glycerine, they instantly appear luminous. For example, a mouse-hair is acknowledged to be a somewhat difficult object to show satisfactorily by ordinary means, either opaque or transparently; but viewed by this method its structure is unmistakable. There is no false glare, and the pigment cells are seen in their true position in the interior of the hair, which in fact forms the actual receptacle for the light.

But perhaps some of the most remarkable results are obtained with the *Diatoms.* Though these are generally mounted on the glass cover, yet it frequently happens that some have become attached to the surface of the under-slide. It is these alone that are visible by this principle of illumination. The small truncated lens is made to adhere to the under-side by a film of oil of cassia or cloves, and the parabolic condenser used as before directed. Most perfect and apparently detached fragments of the *Diatom* scale are clearly brought out, and its structure proved satisfactorily and in a more reliable manner than by any other mode of illumination that I have yet seen, as it is only those parts of the scale in actual contact where total reflexion is destroyed that are visible, consisting perhaps of part of the mid-rib, and a row of dots here and there, or square or triangular patches, according to the species, and very frequently a little isolated group of only three or four nodules together.

It was my intention to have illustrated some of these appearances with camera lucida drawings, but I have now no time for such pursuits; but as the truncated lenses are inexpensive, I trust that some one may be at the pains of employing them as a means of investigating these objects.

VII.—*On the Rhizopodal Fauna of the Deep Sea.*

By William B. Carpenter, M.D., V.P.R.S.

In a paper laid before the Royal Society at its last Sessional Meeting Dr. Carpenter commences by referring to the knowledge of the Rhizopodal Fauna of the Deep Sea which has been gradually acquired by the examination of specimens of the bottom, brought up by the sounding-apparatus; and states that whilst this method of investigation has made known the vast extent and diffusion of Foraminiferal life at great depths, especially in the case of *Globigerina-mud*, which has been proved to cover a large part of the bottom of the North Atlantic Ocean, it has not added any new types to those discoverable in comparatively shallow waters. With the exception of a few forms, which, like *Globigerina*, find their most congenial home, and attain their greatest development, at great depths, the general rule has seemed to be that Foraminifera are progressively dwarfed in proportion to increase of depth, as they are changed from a warmer to a colder climate; those which are brought up from great depths in the equatorial region bearing a much stronger resemblance to those of the colder, temperate, or even of the Arctic seas, than to the littoral forms of their own region.

The author then refers to the recent researches of Professor Huxley upon the indefinite protoplasmic expansion which he names Bathybius, and which seems to extend itself over the ocean-bottom under great varieties of depth and temperature, as among the most important of the results obtained by the sounding-apparatus.

By the recent extension of dredging operations, however, to depths previously considered beyond their reach, very important additions have been made to the Foraminiferal Fauna of the Deep Sea. Several new generic types have been discovered, and new and remarkable varieties of types previously known have presented themselves. It is not a little curious that all the *new* types belong to the family *Lituolida*,—consisting of Foraminifera which do not form a calcareous shell, but construct a "test" by the agglutination of sand-grains,—which was first constituted as a distinct group in the author's 'Introduction to the Study of Foraminifera' (1862). The first set of specimens described seems referable to the genus *Proteonina* of Professor Williamson; but the test, instead of being composed (as in his specimens) of sand-grains, is constructed of sponge-spicules, cemented together with great regularity, so as to form tubes which are either fusiform or cylindrical, being in the former case usually more or less curved, and in the latter generally straight. Of the genus *Trochammina* (Parker and Jones), many examples were found of considerable size, resembling

Nodosarians in their free moniliform growth, but having their tests constructed of sand-grains very firmly cemented together, with an intermixture of fragments of sponge-spicules, which give a hispid character to the surface.—The genus *Rhabdammina* of Professor Sars is based on a species (the *R. abyssorum*) first obtained in his son's dredgings, of which the test is very regularly triradiate, sometimes quadriradiate, and is composed of sand-grains very regularly arranged, and firmly united by a ferruginous cement. Not only was this type represented by numerous species in the 'Lightning' dredgings, but another yet more considerable collection was formed of irregularly radiating and branching tubes, which are composed of an admixture of sand-grains and sponge-spicules, united by ferruginous cement. These seem to originate in a "primordial chamber" of the same material, which extends itself into a tube that afterwards branches indefinitely. This type may be designated *R. irregularis*.—Of the protean genus *Lituola* (Lamarck), a large example was met with, which bears a strong resemblance to the *L. Soldani* of the Sienna Tertiaries. Its nearly cylindrical test is composed of sand-grains very loosely aggregated together, forming a thick wall; and its cavity is divided by septa of the same material into a succession of chambers, arranged in rectilineal series, each having a central orifice prolonged into a short tube.—The genus *Astrorhiza*, instituted a few years ago by Dr. O. Landahl, was represented by a wide range of forms, referable to two principal types, the one an oblate spheroid, with irregular radiating prolongations, the other more resembling a stag's horn, with numerous dentations passing into one another by insensible gradations. The composition of the thick arenaceous test is exactly the same as that of the test of the *Lituola* found on the same bottom; but its cavity is undivided, and there is no proper orifice, the pseudopodial extensions having apparently found their way out between the sand-grains that formed the terminations of the radiating extensions or digitations.—The genus *Saccamina* (Sars) is characterized by a very regular spherical test, built up of large angular sand-grains strongly united by ferruginous cement, which are so arranged as to form a wall-surface well smoothed off externally, whilst its interior is roughened by their angular projections. The cavity is undivided, and is furnished with a single orifice, which is surrounded by a tubular prolongation of the test, giving to the whole the aspect of a globular flask.

The family Miliolida, consisting of Porcellanous-shelled Foraminifera, was represented at the depth of 530 fathoms by a *Cornuspira foliacea* of extraordinary size; and at the depth of 650 fathoms by a series of *Biloculinæ*, of dimensions not elsewhere seen except in tropical or subtropical regions.

Of the family Globigerinida a considerable number of forms

presented themselves; but, with the exception of the ordinary *Globigerina* and *Orbulina*, these were not remarkable either for number or size. The *Globigerina-mud* brought up in large masses by the dredge exhibited the same characters as had been previously determined by the examination of soundings; but it included a large amount of animal life of higher types, whilst it seemed everywhere permeated by the protoplasmic *Bathybius* of Huxley, as described in the author's 'Preliminary Report.' The *Globigerinæ* vary enormously in size; and the author gives reason for the belief that this variation is not the result of growth, but that the small as well as the large individuals have, speaking generally, attained their full dimensions. He describes the sarcodic body obtained by the decalcification of the shell, and discusses the question whether (as some suppose) *Orbulina* is the reproductive segment of *Globigerina*, as to which he inclines to a negative conclusion. He describes the curious manner in which the shells of *Globigerinæ* are worked-up into cases for Tubicolar Annelids; of which cases several different types presented themselves, the Foraminiferal shells in some of them being combined with sponge-spicules. A remarkably fine specimen of *Textularia* was met with alive, of which the porous shell was encased by sand-glains; this being laid open by section showed the sarcodic body of an olive-greenish hue, corresponding with that of the *Lituolæ* and *Astrorhizæ*, also found alive.

The family Lagenida was represented by a large and beautiful living *Cristellaria*, that closely corresponds with one of the forms described by Fichtel and Moll from the Siennese Tertiaries, whilst even exceeding it in dimensions.

These results conclusively show that reduction in the size of *Foraminifera* cannot be attributed to increase of pressure, since the examples of *Cornuspira*, *Biloculina*, and *Cristellaria* found at depths exceeding 500 fathoms, were *far larger* than any that are known to exist in the shallower waters of the colder temperate zone. But as these all occurred in the *warm area*, whose bottom-temperature indicates a movement of waters from the equatorial towards the polar region, it is probable that their size is related to the *temperature* of their habitat, which is found to be in like relation to the general character of the Fauna of which they formed part. On the other hand, as we now know that the climate of the deepest parts of the ocean-bottom, even in equatorial regions, has often (if not universally) Arctic coldness, the dwarfing of the abyssal *Foraminifera* of those regions is fully accounted for on the same principle.

Besides these examples of new or remarkable forms of *Foraminifera*, the 'Lightning' dredgings yielded some peculiar bodies, the examination of which would seem to throw light upon the obscure question of the mode of reproduction in this group. One set of these are cysts, of various shapes and sizes, composed of sand-grains loosely

aggregated, as in the tests of *Lituola* and *Astrorhzia*, which, when broken open, are found to be filled with aggregations of minute yellow spherules, not enclosed in any distinct envelope. These are supposed by the author to be *reproductive gemmules* formed by the segmentation of the sarcodic body of a Rhizopod, in the same manner as zoospores are formed in protophytes by the segmentation of their endochrome. Of such segmentation he formerly described indications in the sarcodic body of *Orbitolites*; and corresponding phenomena have been witnessed by Prof. Max Schulze. But in another set of cysts, of similar materials but of firmer structure, bodies are found having all the characters of *ova*, with *embryos* in various stages of development. In none of these, however, does the embryo present characters sufficiently distinctive to enable its nature to be determined; and the hypothesis of the Foraminiferal origin of these bodies chiefly rests upon the conformity in the structure of the wall of the cysts with that of the tests of *Lituola* and *Astrorhiza*, and upon the improbability that such cysts should have been constructed by animals of any higher type.

PROGRESS OF MICROSCOPICAL SCIENCE.

The Structure of the Cerebral Hemispheres.—On this subject a paper of considerable length was taken as read at the last meeting of the Royal Society, and will appear at length in the forthcoming number of the 'Proceedings.' The paper was by Dr. W. D. Broadbent. The object of the investigation was twofold. First and chiefly, to endeavour to ascertain minutely the course of the fibres by which the convolutions of the hemisphere are connected with each other and with the crus and central ganglia. Secondly, to endeavour to ascertain whether there is a constant similarity between the corresponding sides of different brains as compared with the opposite sides of the same brain; and should this be the case, to endeavour to trace the relation between any anatomical difference which might be discovered and such physiological difference as seems in the present state of our knowledge to be indicated by the association of loss of the faculty of language with disease of the *left* hemisphere rather than the right. Dr. Broadbent's paper relates almost exclusively to the first branch of the investigation, and the method pursued has been to harden the brain by prolonged immersion in strong spirit, by which the fibres are rendered perfectly distinct and fairly tenacious, so that with care and patience their course and arrangement may be accurately ascertained. Previous researches on the structure of the cerebrum have been mainly directed to the examination of the course and distribution of the fibres radiating from the crus and central ganglia, which have been assumed or supposed to occupy ultimately the axis of every convolution, the different convolutions being connected by fibres which crossed under the sulci from one to another. In this paper of Dr. Broadbent's it is shown that the commissural communication between different parts of the hemisphere is much more extensive than has hitherto been described, and that the fibres more commonly run longitudinally in the convolutions than cross from one to another, while large tracts of convolutions have no direct connection with the crus, central ganglia, or corpus callosum. The details of the paper are too numerous for reproduction here.

Photo-micrography applied to Class Demonstrations.—Colonel Dr. Woodward, of the United States Army, recently [May 31st] delivered a lecture on this important subject before the Biological and Microscopical Section of the Academy of Natural Sciences of Philadelphia. A very long abstract of the lecture is published in the American 'Dental Cosmos' for August, and from this we take the following account:—The lecturer, after stating that it was found to be impracticable, if not impossible, to exhibit, with any satisfactory degree of correctness, to a large class or assemblage, such microscopical preparations as require the use of high powers, even though aided by the oxyhydrogen or other powerful lights, explained how his attention came to be given to photo-micrography. The great field promised by the pursuit of this branch of microscopy had already induced some

to make attempts, among whom may be mentioned Donné, Prof. Gerlach, of Erlangen; Joseph Albert, of Munich; and Dr. R. L. Maddox, of Southampton, which proved that great usefulness could be claimed for the method. In America, Prof. O. N. Rood,* of Columbia College, Mr. Lewis M. Rutherfurd, of New York, and Dr. John Dean, of Boston, must be mentioned; the latter having illustrated a paper on the spinal cord by photo-micrographs reproduced by photo-lithography, the magnifying powers not exceeding ten or twelve diameters, while both the former gentlemen had experimented with very high powers. Mr. Rutherfurd had published a paper upon Astronomical Photography,† which contained many suggestions that the lecturer took advantage of; and, after an interview with that gentleman, in which the plan of constructing the objective, the use of the ammonio-sulphate of copper, and the substitution of a properly constructed concave for the eye-piece, were discussed, he determined to develop these suggestions, and assigned to Assistant-Surgeon and Brevet-Major Edward Curtis, U.S.A., the duty of carrying out the manipulations; to this gentleman he expressed his indebtedness for the successful issue of the experiments. The results attained were admitted by Dr. Maddox, who is one of the most successful labourers in this direction in Europe, and by other European *savans*, as most satisfactory, excelling anything heretofore done in this branch. To obtain successful photo-micrographs the following principles are involved:—1. To use objectives so corrected as to bring the actinic ray to a focus. 2. To illuminate by direct sunlight passed through a solution of ammonio-sulphate of copper, which excludes practically all but the actinic extremity of the spectrum. 3. Where it is desired to increase the power of any objective, to use a properly constructed acromatic concave instead of an eye-piece. 4. To focus on plate-glass with a focussing glass, instead of on ground glass. 5. With high powers to use a heliostat to preserve steady illumination. 6. Where an object exhibits interference phenomena when illuminated with parallel rays, as is the case with certain diatoms and many of the soft tissues, to produce a proper diffusion of the rays by the interposition of one or more plates of ground glass in the illuminating pencil. The manipulations are made in a dark room, or rather one faintly illumined by yellow light; the light used in the process of photographing being admitted by a small brass tube, and is obtained from a mirror, which reflects the rays of the sun from a Silbermann's heliostat, through the ammonio-sulphate cell before they enter the brass tube. When the plate of ground glass is used, it is placed between the mirror and the condenser, the diminution of light being overcome by a bull's-eye, where this may be necessary, as in the use of the higher powers. In order to enable those present to judge of the perfection of the work, he had the representations of some of the familiar test objects exhibited: first, there were thrown upon the screen, from photo-micrographic

* "On the Practical Application of Photography to the Microscope." By Prof. O. N. Rood. Vol. xxxii., p. 186, 'Am. Journal of Science and Arts.'

† "Astronomical Photography." By Lewis M. Rutherfurd. 'Am. Jour. Sci. and Arts,' xxxix., 304.

slides placed in a oxyhydrogen lantern, seven representations of— The NAVICULA ANGULATUM, the original object being $\frac{1}{110}$ long, and marked by 52,000 striæ to the inch. These were photographed upon the lantern slides, magnified as follows: 12, 118, 370, 1562, 2344, 9525, and 19,050 diameters, which gave a series of pictures upon the screen, the linear diameters of which were forty times the above, or, 480, 4720, 14,800, 62,480, 93,760, 381,000, and 762,000; the latter being in superficial measurement, 762,000 × 762,000, which equals the enormous size of 580,644 millions of times that of the original. These were particularly interesting, since they exhibited the varied appearance of the object when under the different powers, passing from what appear to be two sets of oblique parallel lines crossing each other, to hexagonal, and finally, under the last to circular markings;* which, however, on moving some distance from the screen, seemed to again change into hexagons. The PODURA PLUMBEA SCALE was the next object. The insect from which this test object is obtained is from the $\frac{1}{10}$ to the $\frac{1}{20}$ of an inch in length, and the scale represented in these photographs is the $\frac{1}{300}$ of an inch long, each spike upon this being about $\frac{1}{4000}$ of an inch in length. Three specimens were shown, which were magnified 522, 756, and 2100 diameters, giving on the screen 20,800, 30,240, and 84,000 linear diameters; these gave most satisfactory representations of the spikes, which seemed to be so clear and well defined as to leave but little doubt as to their shape and structure. The PLEUROSIGMA FORMOSUM, $\frac{1}{60}$th of an inch in length, and having 36,000 striæ to the inch, was × 640 and 2540, or 25,600, and 101,600 diameters upon the screen. Finally, to conclude the series, the TEST PLATE OF NOBERT—which is regarded as the most accurate means of determining defining power—had been photographed, and the slides were brought for exhibition. This optician has issued these plates with lines gradually increasing in fineness; and his latest works have exceeded any of the former in this respect. The first test plate had ten bands, which were ruled at the rates of 443—1964 lines to the millimeter. The second plate, prepared in 1849, had twelve bands; the third plate had fifteen bands, the last one of which was ruled at the rate of 2216 lines to the millimeter. The plates of 1852 had twenty bands, the finest being 2664 to the millimeter; this was described by Mr. Richard Beck, who, with a $\frac{1}{8}$th and No. 3 eye-piece × 1300, found thirty-five lines, each about $\frac{1}{70000}$th of an English inch apart. Nobert next prepared a thirty-band test plate, the thirtieth band of which had 3544 lines to the millimeter. This was the plate described by Sullivant and Wormley.† The last plates made by Nobert have nineteen bands, the 15th corresponding to the lines of the 20th band of the 30-band plate, and the 19th ruled at the rate of 4430 lines to the millimeter. Dr. Woodward gave a somewhat extended description of his investigations in this direction, for an account of which the reader is referred to his paper in the

* "On the Evidence furnished by Photography as to the Nature of the Markings on the Pleurosigma Angulatum." By Prof. O. N. Rood, 'Am. Journal of Science and Arts,' vol. xxxii., p. 335.

† 'American Journal of Science and Arts,' January, 1861.

'London Microscopical Journal' for 1868. At the time he published that article no microscopist had succeeded in seeing the true lines in any of the bands in this plate beyond the 15th. This spring, however, with a Powell and Lealand immersion $\frac{1}{16}$th, he had resolved the four higher bands, and now showed photographs of them. These bands presented the following number of lines,—the 16th 48, the 17th 51, the 18th 54, and the 19th 57, each in about $\frac{1}{2000}$th of an inch. Papers announcing this success had been sent to the 'MONTHLY MICROSCOPICAL JOURNAL' and to 'Silliman's Journal.' A number of anatomical objects was also exhibited.

The Origin of the Gall-ducts.—Dr. R. Cresson Stiles, of New York, has been studying the livers of cattle which have died of hepatic disease in which the bile-ducts became charged with biliary matter, and he believes that his researches have led him to accurate conclusions as to the mode of termination of these canals. He thinks he has proved the existence of minute terminal reticulations, and states that he has demonstrated them to the New York Academy of Medicine. He writes as follows to one of the New York medical journals:— "Let it be understood that I have nowhere claimed to have made a 'discovery,' but simply to have made certain what others believed they had demonstrated, although their opinions have not received the support of the highest authorities in histology. The following passage, from Kölliker's 'Handbuch der Gewebelehre,' will show precisely what I have seen and demonstrated before the New York Academy of Medicine, and to a large number of skilled histologists: —'The teachings of *Budge* and *Schmidt* are entirely different, which are, that they believe they have demonstrated, by means of injection, in the interior of the acini, between the liver cells, the finest gall-ducts. According to *Budge*, the gall-ducts suddenly contract at the surface of the acinus to ·002''', and fine canals of this calibre extend in the form of a network between the liver-cells throughout the acinus. *Schmidt's* confused statements may be seen in his work, which, however, is endorsed by another worker, to the effect that he has injected from the gall-ducts a network of fine canals of the ·0013 of a millimètre to the ·0014 mm. which pervades the entire acinus, and in such wise that the canals never run by the side of the blood-vessels, but only between the cells of the liver. All these canals are perfectly cylindrical, and apparently of the same thickness, yet a *membrana propria* cannot be demonstrated.' Kölliker regards these canals (as he has not seen the preparations of the histologists whose opinion he combats) as formed by the escape of the injecting material. My own observations on the gall-ducts injected by the tenacious bile peculiar to the Texas cattle disease, prove that this explanation is inadmissible. Kölliker says, furthermore, '*Reichert* and *Henle* have thought of lymphatics. The tenuity of the canals in question would not invalidate this opinion, as *Henle* believes, for the larvæ of frogs have just as fine lymphatics with walls; but the presence of fine canals in the *interior* of the framework of liver-cells, as far as I understand the development of the liver, makes this opinion entirely untenable.' Should this network be one of lymphatics, it is one of

lymphatics which empty into the gall-ducts between the acini, into which I have distinctly traced them."

The Leaves of Coniferæ.—Mr. Thomas Meehan has laid a short memoir on this subject before the "American Association for the Advancement of Science," and which will appear in the forthcoming volume of the 'Transactions.' He analyzes the opinions of Drs. Dickson and Engelman, and having described some of his observations on the relation of the old fasicles to the woody system of the tree, he concludes:—(1) That the true leaves of Coniferæ are usually adnate with the branches. (2) Adnation is in proportion to vigour in the genus, species, or in the individuals of the same species or branches of the same individual. (3) Many so-called distinct species of coniferæ are the same, but in various states of "adnation."

The Structure of Brunner's Glands.—A memoir on the anatomy of these intestinal glands was read before the Vienna Academy of Sciences, at its last meeting for the present session (July 15). It was written by Herr Anton Schlemmer, of the Physiological Institute of the Vienna University. The author alleges that these glands are not racemose, as generally asserted, but are tubular. The memoir is not yet published in full.

The Distribution of the Tracheal Vessels in Ferns.—M. A. Trécul has published some of the results of his researches in a very long communication to the 'Comptes Rendus,' of July 26th. The author refers to the great difficulty of explaining his observations without figures. It would then be impossible for us in a few lines to give any adequate idea of the author's views. We may mention that he goes minutely into the investigation of the vascular system of ferns, and describes the arrangement of the tracheal vessels in from twenty to thirty different species.

A New Hermaphroditic Borlasia.—M. A. F. Marion has discovered on the coast of Marseilles a new species of Borlasia, which, like the *B. hermaphroditica* of Professor Keferstein, is monœcious. He calls it *B. Kefersteinii*, and describes its reproductive apparatus. It measures $15^{mm.}$ in length, and is covered with vibritile cilia. Both male and female "ovules," as the discoverer calls them, are developed between the hepatic layer of the digestive tube and the walls of the body. The female ovule measures $\cdot 317^{mm.}$, the males are smaller, and are filled with zoosperms.

NOTES AND MEMORANDA.

Parallel-rays Condensing Illuminator.—Dr. Royston Pigott sends us a sketch and account of an instrument devised by him, and to which he has given the above name. The instrument was constructed for him by Messrs. Powell and Lealand, and "with it a very intense set

of parallel rays can be thrown upon the object at any required degree of obliquity." He found the Podura beads were shown with it very satisfactorily, and he states that "it has the advantage of regulating obliquity to a great nicety, and giving a pencil of rays producing in some cases a fine definition." The illuminator itself consists of three plano-convex lenses, one of which, that on which the light falls, is of 2-inch focus, and the two others of which have respectively a 1-inch and a ½-inch focus. The large and the small lens are adjustable by means of a sliding cap. The movements of the illuminator (which can be effected with any degree of obliquity) are provided for by a graduated arc, which fits beneath the stage of the microscope, and on which the illuminator works.

A suggested Plan for Dark-ground and Oblique Illumination.—A correspondent gives the following brief description of a method employed for the above purpose:—Let a square be cut parallel to the base from a square or hexagonal pyramid of glass, grind and polish its edges to four or six different angles to suit various object-glasses. Drill a hole through its centre, and mount with slotted diaphragm to fit substage. The prism thus formed may be plain or tinted glass, any edge may be achromatized by a small flint prism or cylindrical lens of requisite curve cemented to its under-surface. The bull's-eye condenser, and stage-mirror are used for illumination. A *flat line of light* is thrown obliquely upon the object, well adapted to bring out markings on tests. Cylindrical lenses might also be employed for the same purpose.

Prizes for Collections.—The Committee of the Belfast Naturalists' Field Club offer a number of prizes for the best collections of various Natural History objects, Some of the prizes are valuable. The one devoted to microscopy is not large, but it may eventually develop into something better. It is a prize of 10*s*. for the best set of twenty-five microscopical slides. Prizes to be competed for in March, 1870.

Messrs. Cassell's Estimate of Microscopic Perfection.—Messrs. Cassell announce the fact that, in accordance with a want expressed by readers of their 'Popular Educator,' they "have arranged to supply through the ordinary trade channels, at exceptionally low prices, a series of *first-class microscopes*, many of them designed on new and improved principles, for school use and private study" ('Echo,' Aug. 11th). The following is a description of these first-class instruments (!):—"The Society of Arts' Prize School Microscope, with rack adjustment, 3 powers, giving 656 superficies, with condenser, animalcule-cage, pliers, &c., 10*s*. 6*d*. Ditto, with body and eye piece, converting it into a compound microscope, 13*s*. Superior School Microscope, with joint, achromatic, magnifying powers 400 to 8000 times, in neat mahogany cabinet, 21*s*. Achromatic Microscope, all brass, 3 powers, magnifying 50, 100, or 180 times, in mahogany cabinet, 38*s*. Achromatic Microscope, on bronze stand, very powerful, 45*s*. Ditto, ditto, larger, 50*s*. Compound Achromatic Microscope, on bronze stand, to incline at any angle, with rack-work adjustment, stage, and diaphragms, 63*s*." Those who know anything of micro-

scopes will form their own opinion as to the working capacities of these microscopes, the best and most expensive of which actually possesses "a stage and diaphragms" (!); but the "masses" to whom the advertisement is addressed will, according to custom, take *omne ignotum pro magnifico.* It is quite clear that Messrs. Cassell wish to do good, but that they have not gone the right way about it. On a point of this kind they should have sought the aid of the Royal Microscopical Society, whose Council and officers would have put them in a better position to help scientific education.

The Histology of the Eye is the subject of some recent lectures of Mr. J. W. Hulke, to which we would direct attention. We hope in an early number to give an abstract and illustration of the results of Mr. Hulke's researches.

Immersion Objectives.—In answer to our correspondent, Mr. J. Newton, of Liverpool, we beg to say that the subject is receiving great attention from some of our best workers. The matter is still *sub judice;* but we think we may anticipate the final decision by stating that, if only from their cheapness, the immersion lenses are likely to become very popular in this country. The best glasses are those made by Merz, of Munich, and Hartnack, of Paris. An advertisement of prices of the lenses of the former appeared in an early number of this Journal.

Microscopy in the Peabody Academy.—We have received the first annual report of the Academy of Science founded by Mr. Peabody. We regret to notice that while other departments of physical and natural knowledge have been carefully attended to, there is no mention whatever of a section of microscopy, nor does there seem to be any provision in the new museum for the teaching of histology.

Micro-photographs.—Under the auspices of the Royal Academy of Vienna, M. Martin has been making a series of photographs of microscopic objects. He employed eye-pieces and objectives by Mr. Ladd, of Beak Street, and by Hartnack, of Paris.

CORRESPONDENCE.

The New Universal Dissecting Microscope.

To the Editor of the 'Monthly Microscopical Journal.'

Jersey, *July 15th.*

Sir,—The June number of your Journal contains an account by Mr. W. P. Marshall, President of the Birmingham Natural History and Microscopical Society, of a "new universal mounting and dissecting microscope," which he says has been ably worked out and improved from *his* designs by Messrs. Field, of Birmingham. There is a slight error as to the origin of those designs which I should feel obliged by your allowing me to correct.

The real origin of the instrument is as follows:—Several microscopes for dissecting purposes had been exhibited at our meetings, among others that by Messrs. Smith and Beck. Mr. Marshall afterwards suggested that this might be made more useful by certain modifications embodied in a model which he exhibited and explained, and in which the apparatus was stowed away under the stage, and the case was a square box slipped on from above, like a hood.

The awkward part of this was that it was necessary to remove the apparatus from below the stage before beginning to work. It struck me that if, instead of the case being a square hood, it were made to open (by hinges) away from the stage, the apparatus could all be attached to the case, instead of encumbering the instrument. I made and exhibited at the Birmingham Natural History and Microscopical Society a model (which I have with me now in Jersey), from which most of the ideas appear to have been gleaned for the making of Mr. Marshall's microscope.

May I trespass on your kindness so far as to give a few words of description of my instrument, touching on some of the points of similarity and difference between the two?

In order to use my microscope I place the box on the table, with the lock towards me, lift up the lid and throw it back, open back the two sides (which with the lid are hinged to the back), when the case may be pushed away to a convenient distance, and the instrument is ready for use. The turn-table, hot-plate, &c., are attached to the case, *and not to the stage*, so that I can examine an object, transfer it to the hot-plate, and then varnish it on the turn-table without loss of time in fixing and unfixing.

This is a decided advantage, as if I am mounting a large number of objects I do not have to turn away the microscope arm, move the mirror, and change the stage-plate for the hot-plate, and *vice versâ*, with each individual object, and my turn-table working on the case instead of the stage, I do not have to strain the microscope arm by using it "as a convenient support for the hand when making cement rings."

My model was fitted to receive a compound body, but had not the arrangement for inclining the stand when used as a compound microscope.

Among the apparatus I had a wash-bottle, hot-water bath, small benzoline lamp with mirror and condenser, stage forceps, zoophyte trough, animalcule cage, and several other things, in addition to most of those contained in Mr. Marshall's. These, of course, are, however, mere matters of detail; the part which I claim as being *my sole idea* is the attachment of the entire stock of apparatus to the case, and the hinging together of this case in such a manner as to allow of the case and microscope being separated and brought into use in an instant. The size when packed is nearly a 7-inch cube.

My model was in the hands of one of the London makers at the time Mr. Marshall's was sent to the Royal Microscopical Society, and I was totally unaware that any one was working at the matter until, in May, a friend informed me that Messrs. Field had made up a

microscope very much like mine for sale, and were selling it as Mr. Marshall's.

With all respect to Mr. Marshall, I think it should have been brought out in our joint names, or, at least, I should have been written to before the microscopes were brought before the public.

Charles Adcock, M.R.C.S., &c.,

Corresponding Member (late Hon. Sec.) Birmingham Natural History and Microscopical Society; Resident Medical Officer, Jersey Dispensary.

PROCEEDINGS OF SOCIETIES.*

Oldham Microscopic Society.†

July 13th.—The Chairman, Mr. Pullinger, in opening the proceedings, briefly reviewed the history of the Society, congratulating the members on their increased numerical strength, and the many valuable additions they had made to their stock of working microscopic apparatus during the four years of the Society's existence.

Mr. Waddington read a paper "On our British Mosses," in which he discussed their beauty as microscopic objects, the pleasures and advantages to be derived from their study, their geographical distribution, their economic value, and the part they had probably played in past geologic ages.

It was a pleasure to him, he said, to live at a time when these beautiful objects could be examined and studied with the help of instruments so much superior to those with which the great Linnæus conducted his investigations. Many important corrections and many new discoveries in muscology had been made with our improved means, which were utterly impossible with the old and imperfect instruments. The simple structure of mosses correctly placed them low in the scale of vegetable being. On the one hand, the andriæs and phascums connected them with the more lowly Jungermannias; and, on the other, the sphagnums, with their more complex organization, clearly conducted to the higher cryptogams, thus offering, he thought, a few of the "links" so much clamoured for by the opponents of the development theory. The paper was well illustrated by numerous slides of sections of mosses, many of them contributed by the members generally, all bearing on the points adverted to.

The paper concluded with a lucid explanation of the best modes of mounting and preparing for the microscope the different parts of mosses.

* Secretaries of Societies will greatly oblige us by writing out their reports legibly—especially the technical terms—and by "underlining" words, such as specific names, which must be printed in italics. They will thus ensure accuracy and enhance the value of their proceedings.—Ed. M. M. J.

† Report supplied by Mr. James Nield.

Microscopic Section of Manchester Lower Mosley Street Natural History Society.*

Report of meeting, 15th July, Mr. Chaffers, President, in the chair. Mr. Hyde read a paper "On Pollen and its Functions."

The reproductive organs were mentioned, and their sexual differences noted. The growth of the *anther*, its internal arrangement for the formation of the *pollen*, having been described, the *pollen grains* were next considered. They are formed from a substance called *cellulose*, in the cells of the *anther*, the principal cells dividing so as to form an independent cell. They consist of various substances, as gum, starch, resin, pollinine, &c. *Fovilla* is a very minute granular matter which is contained in *pollen grains*. The *pollen tube* down which the *fovilla* passes is formed of the intine of the granules.

The various markings and grooves on the surface of *pollen* were described, and a large number of specimens were shown to exhibit them, including *Lilium auratum*, *Coboea scandens*, *Amaryllis vittata*, *Amaryllis formossissima*, *Polyanthus narcissus*, the Cotton plant, and about twenty others.

Mr. Armstrong contributed two microscopic objects, *Batrachospermum moniliforme* and the Pond-skimmer, to the Society's cabinet.

Mr. Jackson promised to read a paper upon "Seeds as Microscopic Objects," at the next meeting, 2nd August.

Mr. Jackson was elected Hon. Secretary, in the place of Mr. Wilmot, resigned, through leaving Manchester.

Manchester Circulating Microscopic Cabinet Society.†

Quarterly meeting, held 27th July, 1869, Mr. Horne, President, in the chair.

Mr. Hope read a paper "On the Structure of Ferns," after which the members present exhibited the various slides they had prepared, since last meeting, illustrating that subject.

Mr. Aylward proposed the following resolution, which was seconded by Mr. Armstrong, and carried unanimously: "That during the coming winter session (from October to April), the members of this Society shall study the structure and classification of 'Foraminifera,' and that meetings shall be held monthly during that term, so as to allow the members an opportunity of comparing and exchanging their slides, and of general discussion on the subject."

Resolved that the subject for examination at the next quarterly meeting shall be "Foraminifera." Each member will be expected to bring slides illustrative of that class of objects, and is requested to bring any sand he may have to spare for distribution amongst the members.

Brighton and Sussex Natural History Society.

August 12th.—The President, Mr. Glaisyer, in the chair. A paper was read by Mr. T. W. Wonfor, "On certain Facts in the Life-History of Moths and Butterflies." In rearing *Lepidoptera*, for the

* Report supplied by Mr. Thomas Armstrong.

† Report furnished by the Hon. Secretary.

purpose of determining the possession of a distinctive scale by the males, several facts, some well known, others opposed to generally-received opinions, and others perhaps of a novel character, had forced themselves upon his notice. As was well known, the *Lepidoptera* in passing from the egg to the mature state, underwent the several changes of *larva*, *pupa*, and *imago*. In two, and in some cases in only one of these, did the insect partake of food. For while all were voracious in the larval state, and while many possessed a proboscis of great length, other species did not possess any suctorial apparatus, and therefore could not take food. The parent, as a rule, laid the eggs on or near the food-substance of the larvæ, the gradual development of which, in many transparent eggs, can be watched under the microscope. While the changes are taking place the colour of the egg also changes. As soon as the larva is ready to escape, it eats its way seldom at the apex or *micropyle*, where some writers assert it always escapes, but generally below and at one side. The eggs of many are very beautiful objects for the microscope. The larvæ of various, and some of peculiar forms and habits spend their time in eating and changing their skins. In fact, the chief aim of their existence, at this stage, is storing up vitality to enable them to undergo their further changes; for when supplied with insufficient food, or alternately starved and fed, the imago stage is either not reached, or a mutilated or deformed insect results. When the time arrives for the change to the proper state, some construct elaborate cocoons, others suspend themselves from twigs, &c., others burrow, all casting the last larval coat, when they become chrysalides. Just before the final change, the colour of the chrysalis alters, and through the pupa-case the several parts of the future insect may be made out. At last the pupa-case bursts, and the *fully*-fledged insect emerges, with wings of minute size; these expand as air and fluid are forced through them. The scales at the time of emerging are all of full size. This is an important fact, for some assert that the scales expand together with the wing membrane itself, the air breathed-in, entering between the laminæ of each scale; others maintain that the scales are small and few in number in newly-developed insects, but larger and more numerous as the insect advances in age. Both these theories are contrary to fact. If either that portion of the pupa-case which covers the wings be removed a few days before an insect emerges, or the wing of a newly-emerged insect be taken, it will be seen that the scales are *all of full size*, but closely packed together longitudinally and laterally. As the wing membrane expands they are drawn wider and farther apart, until they present the appearance seen on a fully-expanded wing. Experiments made with the Puss moth and Oak eggur, to determine in the first case by what means the insect dissolved its hard cocoon, and in the second to find how the males were attracted, were next described. Several cases of *parthenogenesis*, in which none of the larvæ reached the third moult, and examples of a second copulation, were next mentioned. The females possessed greater vitality than the males, and made, *in articulo mortis*, efforts to lay their eggs, which in some cases for days after death were extruded. While such varied colours were seen in *Lepidoptera*, the scales themselves, when viewed by transmitted light

were either colourless or of a dull yellowish tint. As regarded a distinctive scale on the males, there was not a doubt that in many families the males possessed scales of a peculiar type, known as the "battledore" or "tasselled" scale; further researches might reveal other types. It could very safely be laid down that no female possessed a battledore or tasselled scale, hence wherever found they were indicative of sex. Several other points were advanced, and the life-history of different moths and butterflies described. The paper was illustrated by a collection of insects in the several stages, and by microscopic preparations.

It was resolved that a letter of invitation from the Society to the British Association, requesting the honour of a visit to Brighton, be forwarded through Mr. Mayall, who had consented to represent the Society at Exeter.

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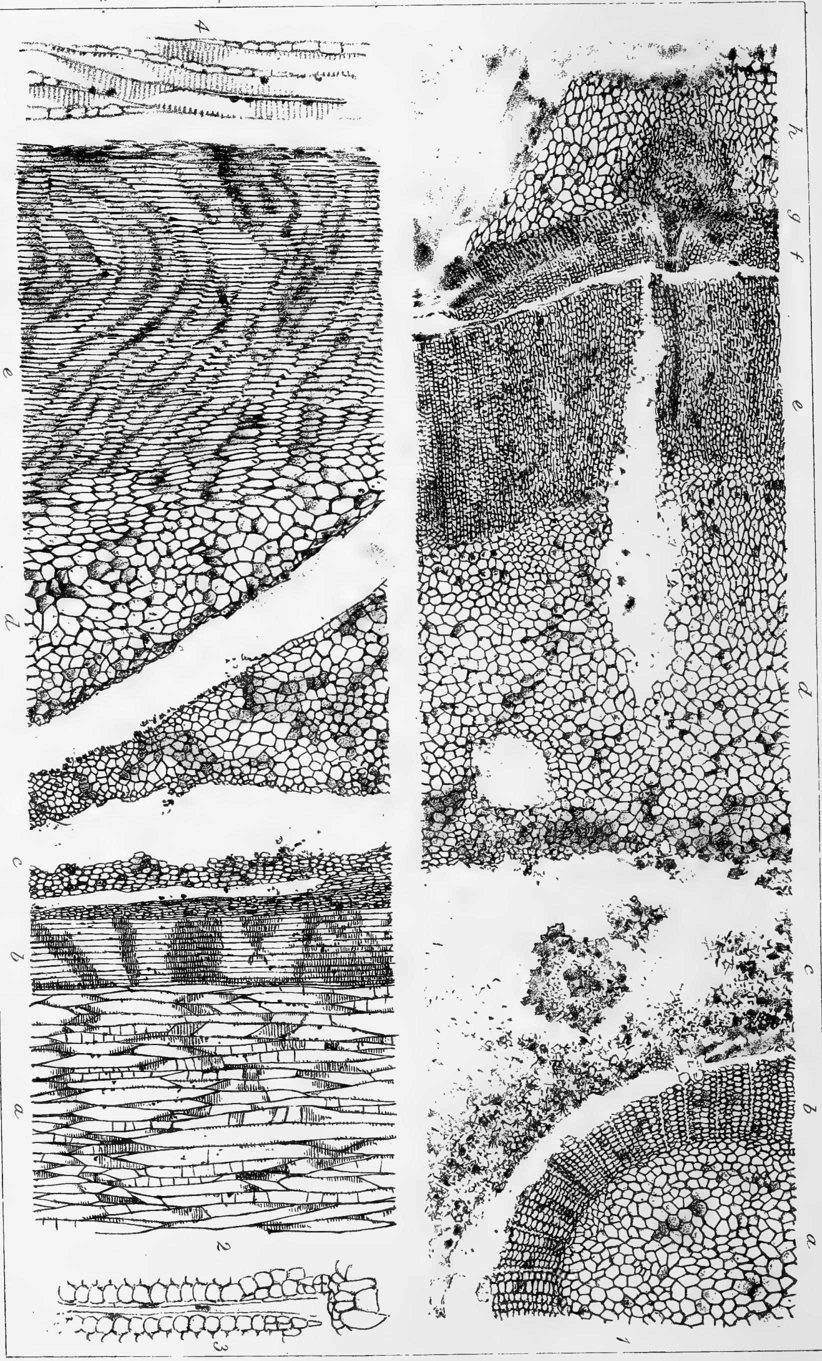

W. G. Smith, ad nat. del. W. West imp.

Lepidodendron selaginoides, – *Sternb.* –

THE

MONTHLY MICROSCOPICAL JOURNAL.

OCTOBER 1, 1869.

I.—*On the Structure of the Stems of the Arborescent Lycopodiaceæ of the Coal Measures.* By W. Carruthers, F.L.S., F.G.S., Botanical Department, British Museum.

(" *Taken as Read*" *before the* Royal Microscopical Society, *June* 9, 1869.)

(Communicated by the President.)

Plate XXVII.

Having for some time been collecting materials for the illustration of the stems of *Sigillaria*, *Lepidodendron*, and other forms of gigantic *Lycopodiaceæ* belonging to the Carboniferous period, I propose to submit to the Society some account of these remarkable structures, and to examine the points of agreement and difference between them and the stems of existing plants.

I have been especially fortunate in obtaining a large collection of fossils from the beds of volcanic ash discovered by E. Wunsch, Esq., in the north-east corner of the Island of Arran, in the Frith of Clyde. Guided by his son, I had myself the pleasure of exploring the beds and of collecting a number of specimens. The rocks are exposed on the shore at Laggan, and consist of a considerable series of volcanic tufas indurated by infiltrated carbonate of lime, alternating with thin beds of hardened shales. Stigmarian roots abound in the shales, and, with not a little difficulty, I removed the superimposed rock and traced the radiating branches of *Stigmaria* proceeding from a large trunk of *Sigillaria*. The different beds of

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EXPLANATION OF PLATE.

Fig. 1.—Transverse section of a portion of the stem of *Lepidodendron selaginoides*, Sternb., from the centre to the circumference. *a.* the axis. *b.* the investing cylinder, both composed of scalariform vessels. *c.* delicate parenchyma, more or less decayed. *d.* stronger parenchyma passing into prosenchyma *e.* *f.* outer layer of the prosenchyma. *g.* the bark. *h.* section through the decurrent base of a leaf.

„ 2.—Longitudinal section of ditto through the centre of the axis. The letters refer to the same structures as in Fig. 1. The open space above the letter *c* arises from the decay of the delicate parenchyma; that above the letter *d*, which passes upwards and outwards, was occupied by a vascular bundle and its associated delicate parenchyma.

„ 3.—One of the cellular rays in transverse section.

„ 4.—Section of several rays at right angles to their direction.

shale formed the soil on which grew extensive cryptogamic forests, that were successively destroyed when in their prime by showers of volcanic ash, which broke down and buried in its mass the branches, and left as bare poles the scorched and dead stems rising high above the ash as witnesses of the terrible destruction. In the course of time they were hidden by the growth of a luxuriant vegetation which speedily covered the new soil, but only to be destroyed by a fresh outburst from the intermittently active volcano in their neighbourhood. Frequently spores found a suitable nidus in the decayed and hollow interior of these immense stems. Mr. Wunsch has given me specimens, in which from six to nine young trees, with stems from two to three inches in diameter, belonging probably to several distinct species and at least to two genera, have grown by the side of each other within a single trunk. The fragments of the branches in the beds of tufa retain to a great extent their original form, and the minute structure is often preserved in a singularly perfect manner. In addition to the specimens I myself collected, I have been supplied in the most liberal manner by Mr. Wunsch with specimens collected by himself. I am also indebted to Mr. J. Young, of the Hunterian Museum, Glasgow, for some interesting specimens he obtained from the same locality.

Professor Morris has supplied me with several important specimens from the Lancashire coal-field. The grant placed at my disposal by the British Association has enabled me to have these various materials prepared by the lapidary, so as to be able to make the most exact microscopical examination of their structure.

In addition to these, I have had the use of several fine preparations from the cabinet of Dr. J. Millar; I have examined the valuable series of microscopic preparations recently acquired by the British Museum, made by Nicol (the inventor of the method of slicing fossils) and Bryson, and the yet more valuable collection made by Robert Brown, and bequeathed by him to the same institution.

The specimens exhibiting structure are generally in nodules in the coal. The conditions which were favourable to the accumulation and preservation of the plant-remains of the Coal period in a state of purity that makes them now invaluable to man, did not also favour the conservation of those characters which would enable us to determine the nature of the plants themselves. With the exception of the thin layers of charcoal, commonly called "Mother-coal," the origin of which has never been satisfactorily accounted for, the whole mass of vegetable matter was speedily reduced to a homogeneous and amorphous condition by decay, greatly assisted by the abundant water. The covering of plastic clay, now indurated into the shale, which invariably forms the "roof" of every good seam of coal, stopped the progress of decomposition, and sealed up the precious deposit against the intrusion of injurious substances like iron or lime. It is only where this cover has been

insufficient to isolate the bed or has had in itself iron or lime, some of which it has parted with, that nodules are found in the coal, making the seam where they occur in quantity of less economic value, but supplying to the naturalist the means to some extent of reading the life history of that period. By the mysterious power of selection and accretion which has formed nodules in sedimentary rocks, fragments of the tissue of the bed have been arrested in their decay, and converted into imperishable limestone. It is seldom that the preserving material has had access to the structures in time to preserve them in their entirety. The more delicate cellular tissue has generally been completely lost. The Arran specimens are remarkable exceptions to this state of things, and this is probably owing to the conditions under which they were buried. The hot ashes, which formed their tomb, appear to have completely charred them, and then, converted into charcoal, they resisted decay and pressure until every cell and cavity was filled by the infiltrated carbonate of lime which converted the loose ashes into a compact stone, and at the same time made permanent in its original form all the most delicate structure of the plant.

The specimen I select first for description is one from the cabinet of Dr. Millar, belonging to the type described by Mr. Binney under the name *Sigillaria vascularis*.* As the specimen belongs to *Lepidodendron selaginoides*, Sternb., I shall employ, in accordance with the invariable practice of naturalists, the older name in speaking of it. I have chosen this species because it is one that may easily be obtained by students. I have it from different localities, and Mr. Binney tells us that the Halifax Hard Seam or Ganister coal at South Ouram, near Halifax, contains in some places so many of the nodules as to render it useless—that they occur over a space of several acres, then almost disappear, but occur again as numerous as before,—and that this has been traced over a distance of twenty-five to thirty miles.

As the technical terms which I shall be obliged to use for perspicuity are somewhat different from those employed by Mr. Binney, there is the more necessity for redescribing this fossil; besides, I shall add some points which I have determined in my examination of the series of specimens which have passed through my hands.

The stem of the *Lepidodendron selaginoides*, portions of which I have figured on the Plate, is somewhat compressed, being 1 inch across its greater diameter and $\frac{3}{4}$ of an inch across its lesser.

The axis of the stem is composed of scalariform vessels of large diameter. In transverse section (Fig. 1 *a*) it is seen to be composed of two parts—1st, a central portion, consisting of vessels of different

* "On some Fossil Plants showing Structure, from the Lower Coal-measures of Lancashire," by E. W. Binney, Esq., F.R.S. 'Quart. Journ. Geol. Soc.,' vol. xviii., p. 106, Pl. IV. and V. The stems described under the same name in the 'Phil. Trans.,' by Mr. Binney, are different, and are consequently not taken into account in the present notice.

sizes, more or less circular or polyhedral in section, and arranged in irregular order; and 2nd, an external portion, in which the vessels have an irregularly radiating direction, their longest diameter being in the line of the radius (this is not well rendered in the plate). The circumference of the axis is regular, from the interspaces between the large vessels being filled in by some of smaller diameter. The vessels are of considerable length (Fig. 2*a*), so that I have not been able to obtain a longitudinal section which would show with certainty both terminations of one. Some of those in the centre of the axis are divided into chambers by horizontal septa, or rather they appear to be made up of a series of short obtuse cells, whose transverse as well as longitudinal sides are marked with scalariform bars. Such interrupted vessels are scattered irregularly through the others. I can detect no trace of any other structure in the axis than scalariform vessels.

Surrounding the axis is a narrow cylinder of radiating scalariform tissue (Fig. 1*b*), differing from that of the axis only in the method of its arrangement, and in the smaller diameter of the vessels. They are seldom more than a quarter of the size of those of the axis, and are smallest at their origin in the interior of the cylinder. Their form in transverse section is sub-quadrangular. They are separated into groups of one, two, three, or four rays by a horizontal radiating structure composed of somewhat elongated cells with truncate ends, and delicate walls without any markings on them (Fig. 3). The cells are from two to four times longer than the diameter of the scalariform vessels of the cylinder, while their transverse diameter is only half that of their vessels. In a longitudinal section at right angles to the radius these cells are seen to be arranged either singly, in longer or shorter linear series, or occasionally in larger wedges composed of two or three cells in thickness (Fig. 4). In addition to this cellular structure there also are seen passing outwards, between meshes in the cylinder of scalariform vessels, bundles of similar but more delicate vessels connected with the leaves. Both these structures are described by M. Brongniart in his *Sigillaria elegans*. The first are his medullary rays. It is obvious that this term is scarcely admissible here, as the axis of the stem is not occupied with a cellular or medullary tissue, but with scalariform vessels. In a recent paper on *Sigillaria* * I ventured to doubt that these were medullary rays, but I was not then able to show that whatever the structure is it cannot be interpreted as similar to that of the medullary system of dicotyledons.

The vascular cylinder is surrounded by a considerable thickness of delicate parenchyma (Figs. 1*c* and 2*c*), which in most specimens has completely disappeared, but in that figured some remains of it exist in the transverse section near the vascular cylinder, and a larger quantity is seen in the longitudinal section (Fig. 2*c*). The

* 'Quart. Journ. Geol. Soc.,' vol. xxv., p. 248.

cells of this layer are small and spherical, with very delicate walls. They were the first portion of the stem structures to decay, and almost invariably the cellular rootlets from Stigmarioid and other roots pushed their way into these decaying cavities, and being there preserved have been mistaken by several observers for portions of the tissues of the stem. The vascular bundles, described as penetrating the vascular cylinder, pass in an upward and then in an outward and upward direction through this layer of parenchyma. Frequently these delicate bundles have been involved in the decay which destroyed the mass of the cells through which they passed, and no record of them remains from their leaving the vascular cylinder until they enter the outer cylinder of more compact tissue. In the specimen figured I have counted twenty-four vascular bundles, either closely adpressed to or adjoining the vascular cylinder.

The next structure in the stem is a layer of larger and thicker walled parenchyma (Figs. 1 *d* and 2 *d*), which, by a gradual lengthening of the cells, and a decrease in their diameter, becomes changed into the regularly arranged prosenchyma of the circumference (Figs. 1 *e* and 2 *e*). These outer cells agree in every respect with true wood cells, being greatly elongated and having pointed extremities, and the method in which they are arranged is very much that of the wood cells in exogenous stems. No indication of any horizontal cellular structure has been detected in this prosenchymatous cylinder corresponding to what has been described in the scalariform tissue. The vascular bundles, accompanied with a certain amount of cellular tissue, pass upwards and outwards through it to the leaves.

In the specimen figured, the outer portion of the prosenchyma (Fig. 1 *f*), consisting of six cells in depth, has a slightly different aspect from the rest, and has been easily detached from it. In position, appearance, and the ease with which it separates from the older structure, it answers to the younger growing portion of the wood in exogenous stems, and may have had a corresponding significance.

Outside this there is a layer of small thick-walled parenchyma (Fig. 1 *g*), from eight to twelve cells thick, forming the external bark.

The vascular bundles can be traced through all these layers into the leaf. As they approach the surface of the stem they have a somewhat circular transverse section. A small quantity of cellular tissue occupies the centre of the bundle. It is its termination in the centre of the characteristic scar of this species which gives the circular depression shown in the figures of the fossil.

The bases of the leaves are persistent, and are composed of roundish parenchyma (Fig. 1 *h*). The leaves themselves seem to have been deciduous, for in a specimen where the section passes through the end of the vascular bundle, the surface of the rhomboidal elevation which supported its leaf is cicatrized, being composed of a layer of small thickened cells.

II.—*Report on Mineral Veins and their Organic Contents in Carboniferous Limestone.* By CHARLES MOORE, F.G.S.

AT the late meeting of the British Association at Exeter I contributed a paper on the above subject, and as many of the organic remains to which I then referred belonged to the *Microzoa*, a short notice of them, and the peculiar circumstances under which they were found, may not be uninteresting to the readers of the 'Monthly Microscopical Journal.' I stated that my attention had for some time been directed to the altered conditions many of the secondary rocks presented when they came in contact with the Carboniferous Limestone of the Mendip Hills, especially when they rested against their southern side. Throughout the whole of the district I found that the Carboniferous Limestone, during the secondary epoch had formed the floor of the sea bottom in the later liassic and Rhœtic periods, that they then became greatly fissured, and received within their walls the minerals and other inorganic contents with which they are now filled, together with the organic remains that were in existence in the seas of the period. These fissures or veins extended throughout the entire length of the Mendip Hills, for a distance of thirty-five miles. At Charter House a shaft had been sunk for lead ore to a depth of 270 feet, and at this distance from the surface I found a deposit of blue clay in the vein, from which I obtained 120 species of organic remains, about 100 of which, though obtained from a vein in Carboniferous Limestone, were really as young as the lias.

The RHIZOPODA thus found I had previously obtained with others in stratified beds of the lower lias,* whilst the Entomostraca appear to be of species hitherto found only in the Carboniferous Limestone.

FORAMINIFERA.

Cristellaria rotula, Lamk.
" *costata*, D'Orb.
Dentalina communis, D'Orb.
" *obliqua*, Linn.
" *obliquestriata*, Reuss.
Frondicularia striatula, Reuss.
Involutina liassica, Jones.
" sp.
Marginulina lituus, D'Orb.
Nodosaria raphanistrum, Linn.
" *radicula*, Linn.
" *paucicostata*, Reuss.
Planularia Bronni, Roem.

ENTOMOSTRACA.

Bairdia plebeia, Reuss.
" *brevis*, Jones and Kirby.
Cythere bilobata, Münst.
" *fabulina*, J. and K.
" *intermedia*, Münst.
" *ambigua*, Jones, M.S.
" *æqualis*, Jones, M.S.
" *spinifera*, Jones, M.S.
" *Thraso*, Jones, M.S.
Kirkbya plicata, J. and K.
Moorea tenuis, Jones, M.S.

* See "Abnormal Conditions of Secondary Deposits," &c., 'Quart. Journ. Geo. Soc.,' p. 473. 1867.

With the above were also associated five genera of land and fresh-water shells.

Extending my observations into North Wales and the north of England, I again found the same general conditions prevail, and that, more or less abundantly, the lead veins yielded organic remains, some of them at great depths.

In the Fallowfield mines and the Silver-band mines, two very minute seeds of the *Flemingites gracilis*, Carr., were found; and since then I have discovered that horizontal beds of the coal-measures are almost wholly composed of them; and I infer that the Fallowfield mine received its minerals and the other contents of the veins subsequently to the coal period.

In many of the veins in districts wide apart I discovered many of those remarkable bodies called *Conodonts* by Pander. They had been found by the latter in Silurian beds in Russia, who, considering them to be the minute teeth of fish, created fifty-six species for their reception. Several kinds have been found by Dr. Harley in the Silurian bone-bed of Ludlow, who has suggested that they belong to Crustacea. They have also lately been noticed by Professor Owen, in a note, in 'Siluria,' p. 544, who also points out the improbability of their being allied to fish. He thinks the simpler forms not unlike the pygidum or tail of minute Entomostraca, but that against this view was the fact that no Entomostraca were found with them; and he then states the probability of their having been united to the soft perishable bodies of naked mollusks or annelids. I found a great variety of curious forms, not only in the lead veins, but also in stratified beds of Carboniferous Limestone, so that their range in the geological series has been greatly extended. I stated that though I might agree with the view of Professor Owen, it was not correct to say that they were not found with Entomostraca; for though this might not be the case in Silurian strata, yet in the Carboniferous Limestone the beds in which they were found were some of them in great part made up of this crustacean. The Conodonts were usually about a line in length, the simpler ones being not unlike that of a minute conical fish-tooth. I have about forty varieties, some of the forms of which are not unlike fish-jaws, whilst others are almost too eccentric and peculiar for separate description.

The *Entomostraca*, though not individually numerous, were present in almost every mineral vein I have examined, consisting of about twenty-nine species, most of which were new. They were included in the genera *Bairdia*, *Beyrichia*, *Cythere*, *Cytherella*, *Kirkbya*, and *Moorea*, the genus *Cythere* having about seventeen species.

Provisional List of Foraminifera and Entomostraca from North of England Mineral Veins.

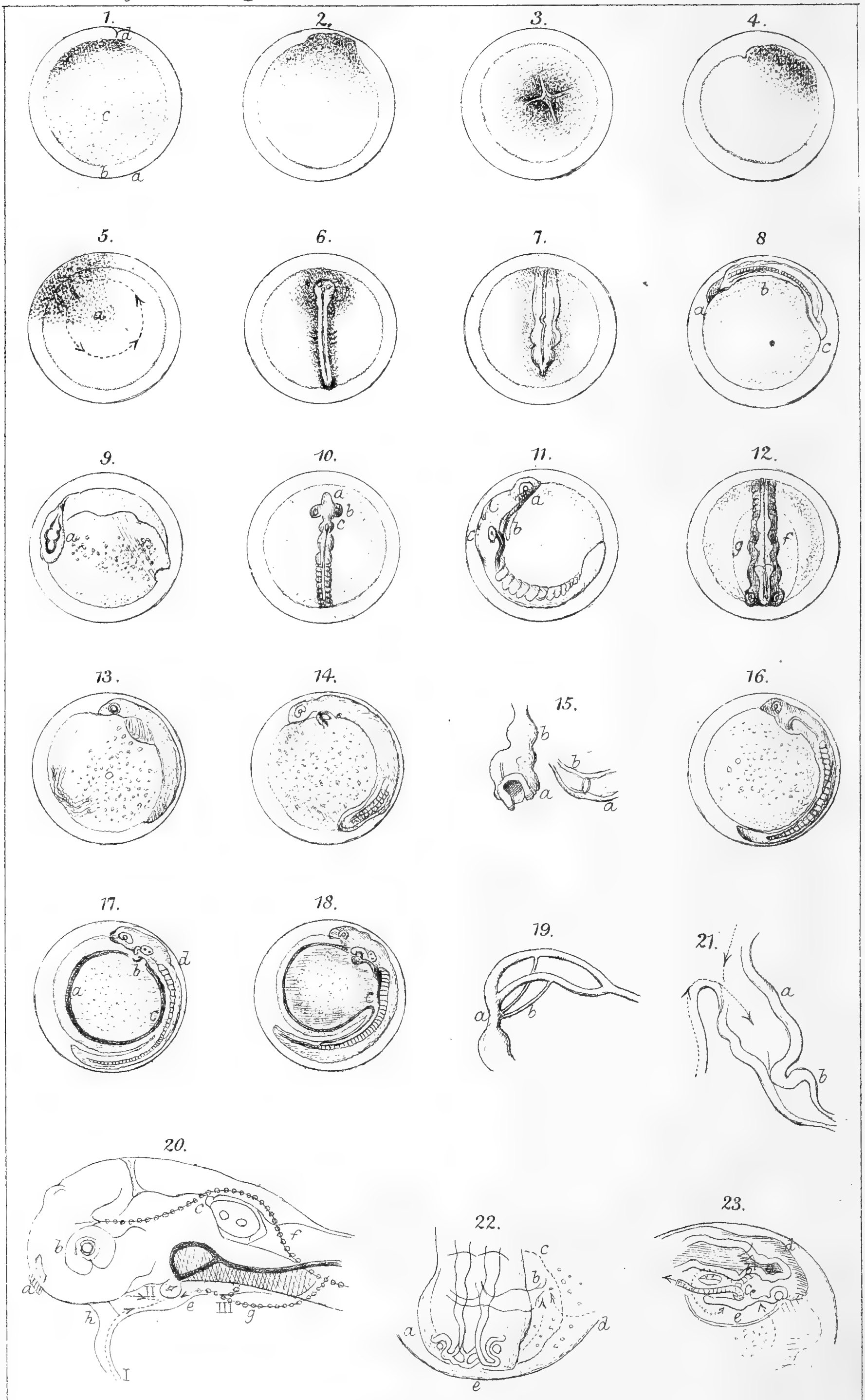
FORAMINIFERA.

Dentalina pauperata, D'Orb.
Fusulina (?), young, sp.
Involutina liassica, Jones.
" *polymorpha*, Terquem.
" *silicea*, Terquem.
" *radiata*, nov. spec.
" *sub-rotunda*, nov. spec.
" *lobata*, nov. spec.
" *crassa*, nov. spec.
" *incurta*, nov. spec.
" *recta*, nov. spec.
" *cylindrica*, nov. spec.
" *obliqua*, nov. spec.
Lituola gigantea (?), nov. spec.
Textularia sagitata, De France.
Tinoporus levis (?), P. and J.

ENTOMOSTRACA.

Bairdia plebeia, Reuss.
" *curta*, McCoy.
Beyrichia, sp.
Cythere bilobata.
" *pyrula*, nov. spec.
" *nigrescens.*
" *munda*, nov. spec.
" *æqualis*, nov. spec.
" *sub-reniformis*, nov. spec.
" *fabulina*, J. and K.
" *antiqua*, nov. spec.
" *Moorei*, Jones, nov. spec.
" *cuneolina*, J. & K., nov. spec.
" *Müensteriana*, J and K., nov. spec.
" *Wardiana*, J. & K., nov. spec.
" nov. spec.
" nov. spec.
Cytherella aspera, Jones, nov. spec.
Leperdita Okeni, Münst.

Foraminifera.—Very little has hitherto been known of this beautiful class of Microzoa from the Carboniferous Limestone, and those I was fortunate enough to obtain from the north of England lead veins will throw considerable light upon them. This will especially apply to the genus *Involutina*, which until lately was only represented by a single living species, the *I. liassica*, Jones; but two had since been figured by Terquem, the *I. polymorpha* and the *I. silicea*, from secondary beds. My series not only carries back the above secondary species to palæozoic times, but associated with them are eight others; so that under these peculiar conditions eleven species of this hitherto little known genus occur. *Dentalina pauperata*, D'Orb., a now living species, which has been traced back through tertiary, liassic, and Permian formations, not only in this series goes back to the Carboniferous Limestone, but I have been fortunate enough to discover a single specimen in the Wenlock shale, an evidence of a delicate microscopic shell having existed through a long series of ages to the present time. The *Tinoporus levis*, P. and J., another recent species, would probably be included in the list, though it requires more examination; added to which would be the recent species *Textularia sagitata*, De France, and also the genus *Fusulina*. Associated with the above were some nearly spherical bodies more or less drawn out at the two poles, as though they had formed portions of a moniliform test. These were suggested by Mr. H. B. Brady, who had examined the series, to be the joints of a large *Lituola*, which he provisionally named *L. gigantea*, though the specimens were too limited for a



E. B. Truman, del. Tuffen West, sc. W. West, imp.

Development of ovum of Pike.

definite or a detailed description.* For the first time there were sixteen species of carboniferous limestone Foraminifera unexpectedly making their appearance in mineral veins, three of which had lived on to the present day, in addition to the liassic forms previously enumerated from Charter House.

In addition to the Microzoa mentioned above, I may remark that from veins and fissures of different ages in the Carboniferous Limestone I obtained remains of the oldest known *Mammalia,* the oldest land and fresh-water mollusca, about 32 species of fish and eight of reptilia; so that altogether, under these peculiar circumstances, I have found about 267 species.

III.—*Observations on the Development of the Ovum of the Pike.* By E. B. Truman, M.D.†

Plates XXVIII., XXIX., and upper half of XXX.

In the spring of 1866 I was engaged in watching closely the wonderful and beautiful changes that take place in the egg of the pike of our rivers, which have for their end the development of an immovable, transparent gelatine-like ball into the most lively, active, and voracious pike, the king of our fresh-water pools and streams. I do not propose to go at any length into the minute anatomical changes which I witnessed, nor shall I permit myself more than is quite unavoidable the use of technical language. I intend here to relate the method of obtaining the supply of eggs, of keeping them alive, and of watching them; and in a general way, the interesting and remarkable sights that are to be seen in a study of this kind. The circulation of the blood throughout a hundred little veins and arteries, the beating of the fountain of life from and to which they pass and return, the growth and formation of the brain, the eye, the ear, and of the viscera, and many other marvellous processes may be viewed by any one who possesses a microscope and a supply of eggs. My purpose is to narrate what I saw, so that others may look for themselves.

In order to obtain a supply of eggs, the pike of both sexes must

* It is a very interesting fact, that within the last few days a bed of Mountain Limestone, of considerable extent and thickness, has been found on the estate of Sir Walter Trevelyan, formed almost entirely of this organism. Whether the fossil really belongs to *Lituola,* or may not yet be another phase of that wonderfully polymorphic type *Involutina,* is a point upon which my friend Mr. Brady is at present engaged.

† The writer desires to state that this paper was originally written for a periodical of a popular character. This will account for many details or explanations in the text which will be unnecessary to the scientific reader.

be taken alive, at a time when they are just ready to deposit their eggs, or to spawn, as it is called. This time will be known to most fresh-water fishermen, whether professional or amateurs. Some one endued with the requisite knowledge of the fish and its habits should be furnished with instructions to look out for pike, male and female, in the state alluded to, and when found, they must be caught in the net, and kept alive in water until they reach the experimenter's or observer's hand.

I obtained my supply of eggs from a friend who was studying the subject of egg development. The pike were netted early in the month of April, the keeper of the (preserved) ponds having been on the watch for a few weeks before. The fish were brought to town and transferred from the fish-can to a tub of cold water. There were two or three specimens of each sex. On the 14th April, 1866, at 10 A.M., a well-grown female fish was taken out of the tub and a wet towel wrapped around her head, with a double purpose—in the first place to maintain a humid atmosphere in the neighbourhood of the gills, so as to keep the respiration process going; in the second place, to prevent any attempt at biting the operator, the pike having powerful jaws and sharp teeth, and being by no means disinclined to resent interference with its liberty. The fish was then laid on a broad, shallow dish, containing a little water, and the four fingers of a hand passed along the sides of the animal with a gentle stroking pressure. By this means, if the fish is ripe, or ready to spawn, the eggs will be found to pass out quite easily, without any force, so to speak, being made use of, and as it is possible to nearly empty the ovary, a great number of eggs is obtained. When a sufficient number was collected, the fish was returned into the water, and a male pike was taken. This was treated in the same way. A very small quantity of the male spawn is sufficient to fertilize the whole number of eggs obtained from a female fish. There is sometimes a difficulty at this stage of the proceedings to get the milt to yield its contents: in such a case the fish may be cut open, and a small piece of the milt placed in the dish containing the eggs, and agitated amongst them for about five minutes. The fragment should then be carefully removed, as otherwise it will decompose, and cause the death of the now fertilized ova.

All that is necessary to do further is to put the eggs into a suitable receptacle (on the bottom of which they should lie at not more than two in depth), to pour in a good quantity of fresh, clean, hard water (from a tap will do), and to cover the vessel with a pane of glass; this keeps out dirt and dust falling upon the eggs—which adhering to them will interfere with microscopic observation—and yet allows of the free passage of light. The water will require changing three or four times a day; this must be done gently, either by decantation or by a syphon. Fresh water must be added

also gently. Addled or dead eggs become opaque white, and should be always removed as soon as seen, as their decomposition will produce further death amongst their neighbours. The living eggs are of a pale yellow, and semi-transparent, having the hue and appearance of gelatine, and apparently quite spherical.

In about five minutes after the eggs were deposited they were found to cohere very strongly. A layer of them, agitated in water, was seen to wave up and down like a woven tissue might, without any break. The occurrence of this cohesion is no doubt a provision for the secure anchorage of the eggs in their native waters; they would adhere to rough stones or gravel in the same way as they adhere *inter se*.

I may state in this place that the magnifying power I made use of during my observations was that afforded by a two-thirds objective, and the low, or No. 1, eye-piece (Smith and Beck), magnifying about 72 diameters. I used this power as it was the lowest I had, but an inch objective will be found sufficiently high for such purposes. Neither is it necessary to purchase a costly microscope; any of the cheaper microscopes of the first London makers will be found sufficient for those whose avocations do not demand, as mine did, a more expensive instrument.

In order to watch the egg in its changes, a little circular, shallow glass cell, fixed by cement on to an ordinary microscopic glass slide, is useful. This cell must be filled brimful of water. To take up the egg, procure a piece of narrow gloss tubing about a foot long and little more than sufficiently wide in the bore to admit of the passage of a single egg at a time. Close one end with the finger, and plunge the tube into the water to a depth of 6 or 8 in.; make the other end approach an egg (which must beforehand be gently loosened if adherent), and remove the finger which closed the tube; a current of water sets in towards the interior of the tube, and carries the egg with it. Replacing the finger on the end of the tube, the egg is retained in the tube and easily carried off. The lower end of the tube is to be moved to the surface of the water in the glass cell, and the egg allowed gently to sink into it, by gradually removing the finger from the tube. The egg and surrounding water are then covered by a piece of thin glass, care being taken to include no bubbles of air; and the whole slide is placed on the stage of the microscope, which stage must be fixed in a horizontal position. Five or six eggs may be included in the cell at the same time, and in this way the egg contents can be observed in several aspects at once.

I will now proceed to describe what I saw by the above means.

Unfertilized ova are found to present some of the phenomena hereafter described, of imbibition of water into its cavity, forming a water-chamber; rotation and contraction of the yelk; sometimes

an imperfect cleavage, &c. So that, when I speak of fertilized ova, I do not necessarily exclude barren ones.

April 14th, 8 P.M.—I did not make any observations until ten hours had elapsed after fertilization; so that my remarks as to what takes place during that time are constructed from what I have heard or read. The egg of the pike is a globular body, the size of, and much resembling in colour and translucency, a grain of cooked sago. It consists of an outer covering, and of a contained yolk or yelk. The outer covering is very elastic, and if an attempt is made to pierce it with a sharp point, the egg springs away; so that it is almost impossible to make an opening. We will suppose that fertilization has taken place, and one of the eggs is placed in the field of the microscope. The first thing observed is that the egg becomes visibly larger in water, and this is seen to be due to an imbibition of water, which enters by absorption through the outer wall, separates the yelk from its previous position in contact with the wall, distends this latter structure, and forms a fluid-medium completely surrounding the globular yelk, and wherein it can freely rotate. This water cavity serves, doubtless, by constant change of the water, as a respiratory medium for the yelk and the embryo fish that is formed upon its surface. Over the surface of the yelk is seen spread out a thin layer of material in the state of granules, or very small particles, which layer is the structure from which the embryo is formed. At first this layer is laid over the whole surface, but collected more especially towards a pole termed the germinal pole, which corresponds to the situation of the micropyle. (See Fig. 1: *a*, the elastic cell-wall; *b*, the water cavity between it; and *c*, the yelk, covered with a layer of granules, which are more densely aggregated towards *d*, the germinal pole and micropyle.) Very shortly, the granular matter collects more markedly at the germinal pole, gradually passes over to it almost entirely, leaving the remaining surface uncovered; and the mass forms a projection on the otherwise circular outline of the yelk (Fig. 2). This germinal mass, consisting of an aggregation of granules, next undergoes cleavage: a furrow forms across it, dividing it into two parts; then another forms at right angles to the first, dividing the whole into four (Fig. 3, where the germinal mass is seen in face, and not in contour). Division goes on into 16, 64, &c., until the mass is minutely divided, and is then in the so-called mulberry stage. It is finally broken up to such a degree that the surface becomes smooth again. It now subsides, as a circular disc, to the under-surface of which is attached a layer of oil-globules.

As soon as the water-breathing chamber is formed, appear the phenomena of contraction and oscillation of the yelk within the yelk cavity. On the circular outline of the yelk appears a shallow in-

dentation: this indentation travels round the yelk and completes the circle. This zone of indentation, which is equatorial, and in the median line, travels onwards towards the germinal pole, the yelk assuming successively the outline of a dumb-bell, a flask, and a sphere surmounted by a little cone. By means of this indentation, the lateral half in which it first occurs is rendered less weighty than the other half, and hence it rises. By this means a swinging movement is set up, whereby the germinal pole moves from side to side, but never passing so low as the horizontal axis of the egg-shell. At first the germinal mass (carried by the yelk) moves almost exactly in a straight line, to and fro; by-and-by, the mass moves in a widely-elliptical orbit around the north pole of the vertical axis of the egg-shell, not dipping below an angle of 45°.

This oscillation takes place now from east to west, now from west to east: a slight interval of time separating the two movements. Variations frequently occur. This oscillation goes on so long as the egg is in vital activity, up to the moment when hatching takes place; and by this rotation the aëration of every part of the embryonic surface by the water around is more completely ensured. (Fig. 5 represents the situation of the orbit in which the germinal mass moves around *a*, the north pole, seen in face.) These movements of oscillation are truly wonderful to witness: the yelk mass moves of itself in an orderly, regular, almost circular round, within the immovable egg-shell.

We spoke of the germinal mass last, as a circular disc, in a state of subdivision. This subdivision goes on until the subdivisions are very small. These cells, as we may call them, aggregate towards the germinal pole of the yelk, and form there a dark and projecting mass. The cells on the outside or periphery of the disc multiply and increase, until the surface of the yelk is covered by their growth. There is, then, a thin layer of cells spread over the yelk, with a central denser portion of a somewhat globular form, and consisting of cells larger than those of the periphery. In my observations the germinal matter had increased by cell multiplication, so as to nearly cover the whole surface in thirty hours after fertilization. On the third day I saw that this mass was divided into two parts by a longitudinal furrow. This is the first rudiment of the embryo, and is known as the "primitive groove." I next observed two straight faint lines, parallel with the primitive groove, extending the whole length of the furrow, marking out the "notochord," or "chorda dorsalis," and also the spinal cord. It is the rudiment of the spinal column. Above this, or "dorsal" to it, is formed the spinal cord: below it, or "ventrally," the nutritive system, heart, viscera, &c. These lines start from one point, and run round the yelk until they reach a point diametrically opposite to the commencement: each termination is surrounded by an outspread layer

of granules. On each side of the median furrow the granules or cells collect, forming a little mound co-extensive with the furrow in length. These mounds eventually arch over the furrow and unite, thus enclosing a space, in which is formed the spinal cord and brain. Running across the two longitudinal lines (the axis of the germ) are lines which represent the vertebral rudiments. (Fig. 6 shows the median furrow, the two straight lines parallel with it, and one extremity of the embryo.) On each side of the median furrow, and above the notochord, is formed the half of the spinal cord and brain, so that the cord contains a cavity within, when the two halves unite above by arching over. At this period we have, next to the yelk, a cylindrical body, the notochord: above it, the spinal-cord rudiment, separated into halves by the median furrow, and terminating in a cephalic, and a caudal, rounded extremity: the whole encircling one-half or three-fourths of the yelk. 40 hours.—The cephalic extremity is pointed: on either side is an inbending of the lateral line, marking off the position of the mesencephalon or middle lobe of the brain (Fig. 7). In profile the embryo is seen to form an elevated mass on the surface of the yelk; the rudiments of four vertebræ, or bones composing the spinal column, are observable, commencing below the cephalic inflection. (Fig. 8: *a*, cephalic extremity; *b*, rudiments of vertebræ, being segmentation or division of the notochord; *c*, caudal extremity.) 52 hours.—The cephalic extremity resembles a leaf of clover, being divided into three lobes: the anterior one, the anterior lobe of the brain; the two lateral lobes, the median lobe of the brain, and the eyes. Behind the middle lobe of the brain is a third and smaller one. (Fig. 9, the three lobes seen laterally, at *a*; a wave of indentation is also seen.) (Fig. 10 shows, *a*, the anterior lobe; *b*, median lobe, with a vesicle on either side, the rudiment of the eye; *c*, the posterior lobe; also several rudimentary vertebræ, and the ventricle or cavity between the halves of the spinal cord.) Twelve vertebral segments are discernible: the cavity occupied by the spinal cord is seen running along their summit. 58 hours.—The spinal cord is seen extending from the eyes to the tail, widening just below the eyes, and then preserving the same width to the tail. It is divided into halves by a median sulcus or furrow. 17*th April*, 10 A.M., 72 hours.—The eye has a central lens, an iris, and a round band encircling both. The ear appears as a somewhat quadrangular capsule, enclosing smaller ones, on the side of the brain mass. The heart also is seen, as a tube bent upon itself, somewhat anterior to the position of the ear. From the heart passes a vessel upwards and towards the tail, but at present it extends no farther than first vertebra. A fold of membrane is reflected from the underpart of the head, which includes the rudimentary heart. (Fig. 11 shows, *a*, the eye; *b*, the including membrane; *c*, the heart, with

the vessel proceeding from it; also the vertebræ, and the rounded tail.) (Fig. 12 shows, *f*, the ear-capsule; *g*, the membrane enclosing the heart; it also shows the union of the halves of the brain in front, and the folding of the mass to form the division between the lobes of the brain; and the median sulcus or canal.) 5 P.M., 79 hours.—The yelk surface is occupied by round clear spaces in which blood-corpuscles can be seen. This was the first time I had seen any, and I had watched very closely for their appearance. By means of the contractions in the yelk, formerly mentioned, the surface is thrown into a series of wavy folds. In the furrows between these little ridges are numerous blood-globules, which are passing towards the præcordial area. There are blood-globules on both right and left sides of the yelk. The præcordial area is of a clear white colour, and empty: no blood as yet has reached it; and it is to be observed that the heart is motionless,—that the blood flows to the heart independently of the heart's action. The blood-corpuscles are colourless at present. The oscillation of the embryo and yelk is vigorous. (Fig. 13 shows the wavy folds which apparently were the means of the movement of the blood-corpuscle on to the heart.) 11.15 P.M., 85¼ hours.—Blood-corpuscles have reached and entered the præcordial area. 11.30 P.M.—There is in the embryo a duct leading from the interior of the yelk into the digestive canal; by this means nourishment is conveyed to the embryo, and it is probable that the yelk contractions are the agents in propelling the yelk into the canal. (Fig. 14 shows this duct.)

18*th April*, 10 *to* 12 A.M., 96 to 98 hours.—For the first time I observed the heart to be beating, yet no blood-corpuscles were passing through it. So that it is evident that the contractions of the heart are independent of any stimulus given by the presence of blood-corpuscles within its chambers. The heart in the adult fish consists, not of four chambers, as in the mammalia, but only of two—first, an auricle to receive and collect blood; immediately succeeding to this a ventricle to contract on the fluid contents and force them onwards. Suceeeding to this is the dilatation of the efferent vessel known as the bulbus arteriosus. In the case before us the heart consisted of a bag-shaped organ, divided into anterior and posterior chambers, the former being the wider of the two, and communicating by a circular constricted portion with the ventricle. The posterior chamber consists of two broad flaps, connected by a thinner structure; the flaps move to and from each other, and thus are capable of producing an intermittency of current by shutting off the supply of blood during the auricular contraction. It may be pointed out that this period is a most favourable one for investigating the nature of the movements of the heart. The structures are all nearly as transparent as glass, and there is no current of blood, so that the conditions are eminently favourable for observa-

tion. The posterior chamber is seen to close-to, like two flat boards coming together; then the anterior one contracts, the contraction travelling along, vermicularly, as it is called, or with a movement like that seen in the locomotion of the earthworm. (Fig. 15: *a*, the posterior, *b*, the anterior chamber; one of the figures shows the flap-like sides of the posterior chamber, the other the circular constriction between the two cavities.) It is interesting to note that at the same time that contractions occur in the heart for the first time, they also occur in the muscles forming along the back of the embryo, which is thus seen to endeavour as it were to straighten itself out.

Coincidently with these changes resulting in the formation of the heart, the formation of the whole body is proceeding with rapidity. By this time the embryo consists of a head, with brain, eyes, and ears, a heart, and a vessel proceeding from it to go down the body underneath the vertebræ, a long chain of vertebræ terminating a little distance from the tail, which latter terminates in a moderately pointed manner; above the vertebral bodies, the spinal cord with its median furrow; these again covered in by muscle and integument. The embryo reposing on and laying around the yelk-bag, from which the creature derives its nourishment, and on the surface of which blood-corpuscles are seen passing to the heart, the whole oscillating within the water-chamber enclosed by the elastic egg-wall.

12.30 P.M., $98\frac{1}{2}$ hours.—The heart beats 104 times per minute. The two cavities contract and dilate alternately; the posterior contracts whilst the anterior dilates, and *vice versâ*. 5.30 P.M., $103\frac{1}{2}$ hours.—By this time, the tail-half is detached from the yelk surface, and is now lying free in the water-chamber (Fig. 16). The yelk-sac is diminishing in size, the growth of the embryo removing the contents gradually by absorption. 10.45 P.M., $108\frac{3}{4}$ hours.—Circulation of blood seen for the first time. At this earliest period the course taken by the blood is as follows:—Two currents of blood are seen passing towards the auricle, one running along the median line of the yelk surface; the other comes from under the body, probably from the other side of the yelk, below a structure situated a little nearer the tail than the heart. These may be called veins. The blood in these two currents uniting, enters the præcordial space, passes through the posterior and anterior cavities, and then, by a large vessel or artery, which immediately divides into two, is carried to the under-surface of the ear, making a sharp curve; two vessels pass as far as to the first vertebra, where they unite, and the united artery passes underneath the vertebræ to a point where the body is disjoined from the yelk. Here the blood runs on to the mid-line of the yelk, and reaches the point whence it started. (Fig. 17: *a*, *b*, the two currents; *d*, the auditory cap-

sule, or ear; *c*, the point where the arterial current runs on to the yelk.) Very soon the arterial current, instead of running on to the yelk at *c*, passes farther along under the vertebral column, makes a very acute bend, and returns by a vein to the yelk (Fig. 18). This prolongation gradually lengthens until the tail-end is reached. 11.45.—Fish, as is well known, breathe by means of gills, or branchiæ. These consist of a multitude of very fine blood-vessels, which lie freely exposed to the surrounding water. At the period last indicated I saw the first rudiments of the branchial apparatus appear. The position of the branchial arteries is represented in Figs. 19 and 20. Fig. 19: *a* is the as yet undivided primitive artery, and *b* one of the branchial arteries. Fig. 20: *d* is a branchial artery represented in position, the one of the other side being unseen; *e* being the heart. Fig. 20 represents a stage more advanced than the present one, but is introduced here to show position of the branchiæ. At this period, 11.45 P.M., I observed a structure (marked by cross-hatching surrounding letter *d*, Fig. 20), obliquely crossing which subsequently became developed the branchial arteries and the supporting arches. At this time I noticed the division of the main trunk into left and right, the left curving upwards and around the rudimental branchial structure running underneath *c*, the auditory capsule, to join its fellow of the right side (not seen). This right trunk passes underneath the head, makes a similar curl upwards and backwards, and, in fact, strictly corresponds to the left one. These may be called the right and left primitive trunks. The heart now appears as a thick walled tube, dilated into posterior and anterior chambers, the former being the larger. The anterior is curved, and the valvular action between it and the posterior consists of an inflection of the wall, whose outside edge is concave, into the cavity of the other wall, fitting like a knee into the hollow, and so shutting off the current. Fig. 21: *a*, posterior chamber; *b*, anterior, with the knee-like valve. Pulse now 90 per minute, being a fall of 14 per minute since 12.30 ($11\frac{1}{4}$ hours ago). Blood-corpuscles are being detached from the yelk surface, where they had their origin, and pass to the opening of the heart. Fig. 22: *a*, the right eye; *b*, posterior chamber—the right primitive trunk is seen passing underneath the head; *c*, the thin line, marks off a space around the heart, a receptacle for the blood before entrance into the heart, which I have called the præcordial area; *d*, the egg-shell. The præcordial area is marked out by a white immovable rim; corpuscles pass through certain gaps which remain constant, as the corpuscles may be seen to pass along the rim for a little distance to reach an opening. Before reaching the rim they advance at a uniform rate; after they have passed the boundary they are repelled slightly with each beating of the heart. There are three currents seen from the left side entering the heart

(marked by three arrows in Fig. 20): one (I) from the left side of the yelk surface; another (II) from the neighbourhood of the mouth, entering anteriorly (and coming from the right side of the yelk surface); the third (III) from the position of the branchial structure, entering posteriorly. The optic capsule (*a*, Fig. 22) is becoming lengthened and curved on itself, so as to form a U-shaped body; in the concavity of this the circular lens is formed. The olfactory capsules, the organs of smell, are visible (the two oval bodies at *e*, one on either side of the middle line) as small depressions in the snout; *f* is the nervous cord which represents the left side of the brain at the present stage. It is seen to unite with its fellow in front, and between the two is a cavity called a ventricle. There are strong movements of flexion in the back, the head bending towards the tail and the tail towards the head.

19*th April*, 6th day, 12.15 noon.—Looking at the right side of the embryo, the right primitive trunk is seen crossing from the left side, making a sudden turn upwards and pursuing a curvilinear horizontal course underneath the organ of hearing, as on the left side. Fig. 23: *c*, same figure; *a*, ventricle of brain; *b*, folding-in of the cerebral cord to form a lobe, the middle or mesocephalic lobe; *d*, the commencement of the left primitive trunk; *e*, the præcordial area—in front and behind this letter are the two currents mentioned as coming from the right side of the yelk surface (Fig. 20). The veins from the head on either side coalesce, and take the course shown (for the left side) in Fig. 20, running from the eye, passing above the auditory capsule, then descending, arrive upon the yelk surface in the præcordial area. On the right side (Fig. 23) it passes under the head. At *g* (Fig. 20) this current and the venous supply from the left side are seen uniting, to pass on to the heart. The venous and arterial currents cross each other, as is seen at *f*, Fig. 20, the artery being underneath. This crossing has led some erroneously to suppose that the two currents, venous and arterial, united.

Fig. 24 is a diagram of these currents: *a*, the cardiac opening; (I) right, (II) left, yelk current; (III) left head venous current; (IV) right ditto. The head is attached to the yelk surface by a broad band (*h*, Fig. 20), and it is posteriorly to this that the current from the right side passes. The optic capsule, mentioned at 11.45 P.M. of 18th, as a U-shaped body, has now the two ends united, so that the lens is encircled (*b*, Fig. 20).

20*th April*, 7th day: 1 A.M., midnight.—A current of blood is seen to pass down the aorta, under the vertebræ, nearly to the end of the tail. The aorta terminates by a small vessel, turning on itself, in a very large vein: the blood runs along the vein to the extremity of the yelk nearest to the tail, and is emptied on to the yelk surface; there being a vein or venous channel on each side of the yelk, which runs on its border to the heart (*d*, Fig. 18).

9.30 A.M.—Two otoliths, or small ear-stones, were seen in the auditory capsule. The little bodies in *c*, Fig. 20, are otoliths. 9.45 A.M.—There are indications of two arches forming, passing along in the situation of the future branchiæ (*d*, Fig. 20). 11.15 P.M.—The embryo has grown completely round the yelk, and the head now touches the tail.

21*st April*, 8th day: 5 P.M. 175 hours.—I found one of the eggs hatched. I had not counted the number of eggs under observation, but find included in the following catalogue 465. Many besides these became addled (being opaque white instead of semi-transparent yellow), and offensive to the nose. These were removed, so that we may estimate the whole of them, in round numbers, at 500. The hatching extended over five days; the majority being hatched on the 23rd April, being the tenth day after fertilization.

On the 14th April I took 500 eggs.

21st, or	8th day,	were hatched	12,	or	2·4	per cent.
22nd „	9th	„ „	143	„	28·6	„
23rd „	10th	„ „	197	„	39·4	„
24th „	11th	„ „	97	„	19·4	„
25th „	12th	„ „	16	„	3·2	„
		add, 35 addled,	35	„	7·0	„
			500		100	

The fish made their exit from the shell, some with the yelk-bag first, some with the tail, the majority with the head: their escape was effected by means of forcible, wriggling contractions of the body. After their exit, some lay motionless at the bottom of the vessel, whilst others, applying the muzzle to the leaf of a water-plant, adhered to it by means of an adhesive material secreted by a gland in that situation, and so hung, suspended from the leaf. This adhesive matter was gradually drawn longer and longer by the weight of the fish, until a thread as long as the little fish itself was formed. Adhesion was seen to be instantaneously effected upon application of the tiny muzzle to the leaf; sometimes there might be seen a cluster of two or three suspended from one point, or a couple hanging from the body of a third.

The recently-hatched fish had not all reached the same stage of development; for whilst in some the movements of the body were vigorous, and the circulation actively going on, others, lying motionless, would show no circulation of blood whatever. At a further stage, as for instance about the 16th or 17th day, at a time when the branchial fringes are in formation, all seemed to be alike with respect to the degree of development.

22*nd April*, 9th day.—State of the circulation immediately after extrusion from the egg. (See Fig. 39.)

The heart (*a*), consisting of posterior and anterior chambers, lies

exposed on the yelk-bag. From the anterior is continued a large arterial trunk, which speedily divides into right and left, the first arterial arch; that for the left side (*b*) passes upwards; the other, for the right side, crosses underneath the head, reaches a similar position and pursues a similar course to that of the left arch. Just before turning along the upper edge of the branchial rudimental structure, each trunk gives off two branches (seen at *c*); the first, a small one, forwards towards the mouth (the orbito-nasal); the second, by far the larger, passes upwards, and supplies the head (the carotid). The diminished trunk makes a great and sudden turn, and runs along the upper edge of the branchial rudiment, and below the ear (*d*). Across the space for the branchiæ are seen stretching two membranous arches, which extend from the heart to the continuation of the first arterial arch. These membranous arches are for the support of a series of vessels, the branchial arteries, four in number (on each side), when complete; the number of bony (as hereafter they are) arches, when complete, being five. Between these two rudimentary arches is seen a faint arterial current passing from the primitive vessel before division to the arterial trunk above, and entering it. At a later hour three spaces were seen, enclosing two blood-currents (as at *e*). These structures, when fully developed, form the gills, or breathing apparatus. The first arterial arch consists of the portion from the heart to *c*. After this point it forms, with its fellow of the opposite side, the aortic circle, extending from *c* to *f*, where it joins its fellow underneath the vertebral axis. From *c*, the half of the circle runs downwards, lying underneath a large vein (the cephalic or jugular), until this vein turns downwards to enter the auricular sinus, a sort of antechamber to the heart (*g*), where the venous current may be seen to cross over the arterial at right angles. From this last point the vessel curves slightly upwards and inwards, joins its fellow, and the conjoined vessel constitutes the aorta. This passes down along the body, being placed between the vertebral structures and the intestine, nearly to the end of the tail. From the whole length of the aorta are given off at regular intervals arteries that pass directly backwards to the dorsal border of the fish, apparently marking out, or running between, the segments of the vertebral axis. (Fig. 25: *a*, spinal cord; *b*, segments of vertebral axis; *c*, intestine; *d*, aorta, giving off vessels.) At the dorsal border these vessels form a system of capillaries, from which return a number of veins similar in number and situation to the arteries, and which ultimately, by means of cross-currents, seen at *m* and *n*, reach the great venous canal lying below the aorta. This channel, the cardinal vein, commences near the extremity of the tail, there being one on each side; the narrowed aorta terminating in them by a complete turn on itself (Fig. 39, *h*). The vein runs along directly underneath or below the aorta, as far as the point

where the intestine turns downwards through the tail membrane to the aperture of exit (*i*). At the bend (*k*) the vein crosses the intestine, and becomes placed underneath it, until it reaches the posterior tapering end of the yelk-bag (*l*, the intestine, traceable upwards to the mouth, the letters *g*, *e*, and *b* being placed on it; and downwards by *k* to its termination, *i*; *m*, the posterior end of the yelk-bag). During its passage from *h* to *m*, it receives, first, a large vein at *k*, which can be traced forwards (mouthwards), lying just below the aorta, and which receives the veins corresponding to the dorsal arteries shown in Fig. 25; from this vein pass two or three communications to the cardinal vein, higher up than the principal junction at *k*, as marked at *n*; 2ndly, a vein, seen at *m*, which turns round the tapering extremity of the yelk-bag, and joins the main vein.

These two veins would appear to return venous blood into the cardinal vein from the body below the point *f*. The cardinal vein thus formed of three conjoined currents passes along the ventral border of the yelk-bag, the blood as yet spreading but little over the sides or general surface; it passes then in the median line around the yelk-bag until it reaches its junction with the mouth (*o*), when it meets current α, then turns inwards and meets current β. This latter current is the return blood from the head (muzzle to *f*), and is formed as follows:—The superficial veins of the head converge from all points to two large veins, which pass one above and the other below the ear (seen above and below *d*); into the one above the ear enters a third, which appears to come from the deep parts of the head. The vein above and that below at length unite behind the ear, and the resulting vein crosses the aortic circle and the intestine, and finally runs out by a round aperture into the auricular sinus (*g*). This is the case on the left side; on the right side, after the blood has reached the surface of the yelk-bag it turns and goes underneath the head; reaching the point *g*, the right and left currents run parallel, a clear interval remaining between them, until they reach the heart, the two forming current β.

A portion of the blood from the right cardinal vein passes along the right side of the yelk-bag to the muzzle, and there crosses over to the left by the junction of the muzzle and yelk-bag, forming current α (seen at *o*). The remainder runs downwards to join the right-side current from the head, which passes under the head to *g*. The current from the left cardinal vein meets current α at the muzzle of the fish, passes onwards to the heart, and at the entrance to the auricle meets current β, coming from a diametrically opposite point; the two run into the auricle by the side nearest to each, mingle, and enter the ventricle—the place whence we started.

In the eye is seen the iris (*s*), a broad band surrounding a round space, a line where two extremities of the band have united being

evident at the lowermost part. In the round space it encloses is the lens, contained in a well-defined capsule; the outline of both is perfectly circular. The mouth, or rather the situation of the future mouth, presents rows of rounded papillæ (*r*), doubtless the source of the adhesive thread by which the fish suspends itself. The duct from the yelk-bag to the intestines is to be seen. The pectoral and dorsal fins are commencing to be developed.

23*rd April*, 10th day.—The primitive trunk seen coming off from the ventricle shows three divisions, two being right and left first arterial arches, the third the main branchial artery, which gives off branches to each side to form the other arterial arches. The rudiments of four branchial arches are now seen between the heart and the aortic circle. Between these arches are seen, in some of the fish, one, in others three arterial currents, the third being very small. These currents enter the aortic circle.

Arterial currents are seen to pass behind the eye, ascending from the region of the mouth, and also in front of the eye, near the olfactory organ (*t*). The venous system appears the same as on the 22nd. I observed that part of the venous return from the head, instead of coming from *g* to the heart, passed tailwards between the intestine and the yelk-bag, and entered the vein which joins the cardinal vein at *m*.

The olfactory organ (*t*) is situated in front of the eye, at the extremity of the muzzle, and has an oval outline. The pectoral fin (*p*) gives faint vibratory movements.

The heart is now becoming more enclosed in the growing branchial structures, and placed more in the middle line. The blood which issues from the cardinal vein on to the yelk-bag is not now confined to the median line, it spreads over the whole surface, running in furrows or channels, having no distinct walls as a vein has. It is streaming all over in numberless paths, all tending to the heart. The object of this is to expose the blood more completely to the action of the water, whereby a respiratory process is effected. The blood, depreciated by its course through the tissues, is no longer sufficiently subjected to the action of the water, owing to the fish growing rapidly and becoming more dense, a greater distance being interposed between the blood-vessels and the water. To remedy this, the great vein distributes its contents over the wide surface of the yelk-bag, where the blood is freely exposed to the surrounding element. In fact, this distribution of the blood in a large number of channels over the yelk-bag is a temporary breathing apparatus, which is designed to effect respiratory changes until the branchiæ or gills are ready to perform that office. (Fig. 26 is an exceedingly rough diagram, showing the course of the blood from *b*, the entrance of the vein on to the yelk-bag, to *a*, the heart.) The ramifications of the vein are very numerous, and the blood-corpuscles hurrying

with great velocity through the winding ways is a most beautiful object to witness.

24th April, 11th day.—In the fully developed state there are five bony arches, called branchial arches; of the four anterior of these each one supports a branchial artery; these four branchial arteries with the first trunk extending from the heart to the aortic circle, constitute the five arterial arches which are given off on each side in the embryo. The second arterial arch, or the first branchial artery, is much increased in diameter, being now as wide a vessel as the first arterial arch; two rudimental branchial bones stretch completely across the branchial region; two others are seen posterior to the first two, and as yet very small.

The circulation of blood over the yelk-sac is more extensively ramified to-day than it was yesterday. Other changes are occurring in the vein mentioned as passing from *g* to *m* (Fig. 39), but as the description would be uninteresting to the general reader, I omit it.

25th April, 12th day.—Slender, well-defined vessels are in process of formation in the membranous expansion around the caudal termination (tail-end) of the fish. They frequently join each other, but do not communicate with any vessel from the heart, being isolated and bloodless. This shows that blood-vessels are laid down, as it were, and grow independently of any connection with the heart. Vessels are also shooting out from the side of the bony axis of the tail, in a direction suitable for meeting the isolated ones mentioned. The branchial arches now bend more decidedly, the convexity being towards the tail. The tail membrane now shows a deep cleft on its dorsal borders, indicating the approaching formation of the dorsal fin (*u*). Pigment cells are beginning to show themselves on the parietes of the body.

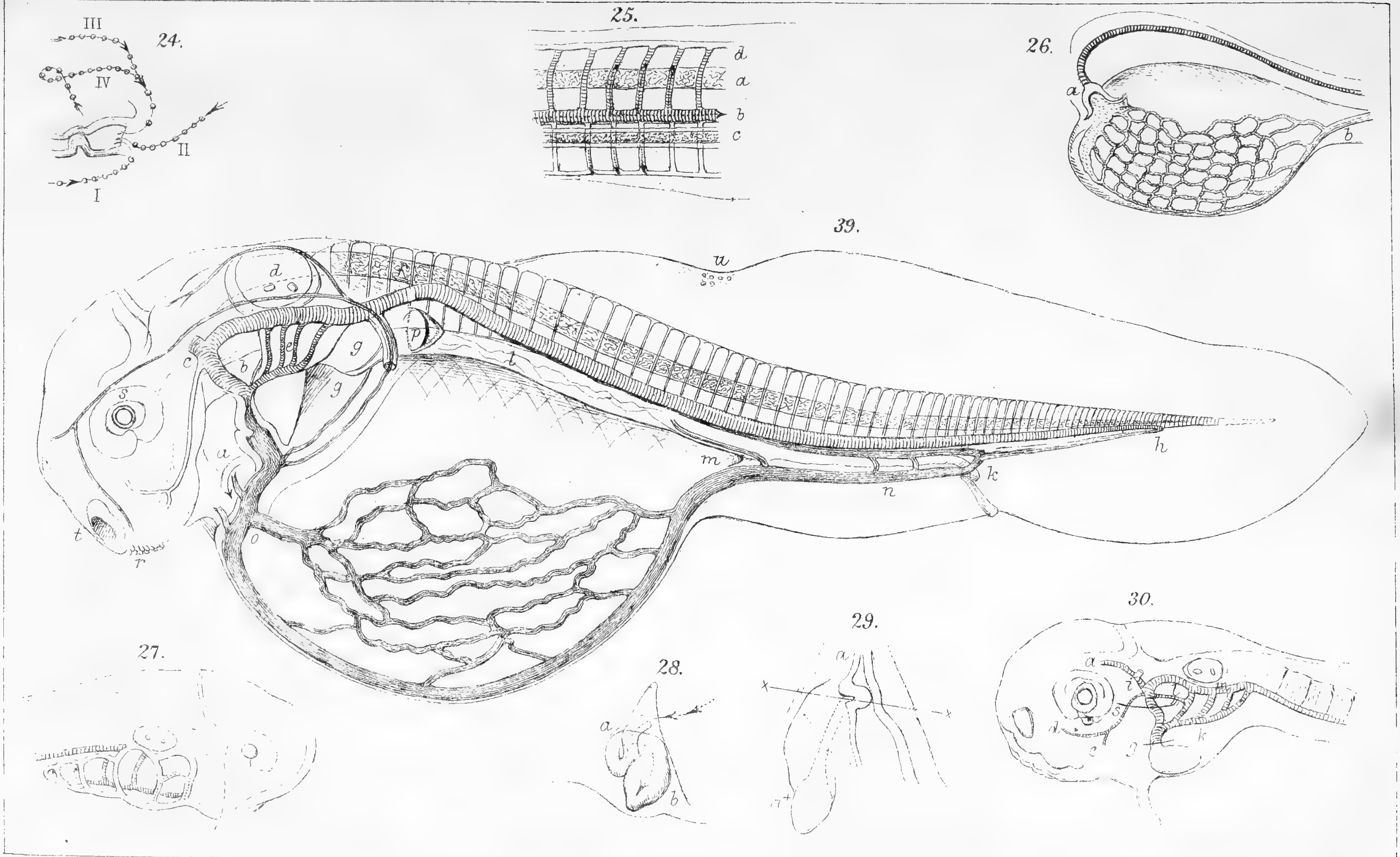
In a fish which had been put into shallow water, under a cover, and which had exhausted apparently all the contained oxygen of the water, the heart's action ceased. The blood ceasing to be impelled forwards from the auricle, that contained in the aortic circle flowed in a reverse direction, backwards. This was interesting, as showing the elastic recoil of the artery. But when by means of the branchial arteries this aortic blood had again reached the heart, it passed completely through it until it reached the auricular sinus. Arrived there, it immediately reverses its course again, enters the heart, causes the heart's pulsation again to take place, and by that means again reaches the branchial arteries and the aorta. I suppose that the blood, having reached this spot, was in a better position for aëration than elsewhere, and therefore more resembled the natural stimulus to the heart's action, as this very strange oscillatory action was repeated many times, the whole lasting some few minutes.

26th April, 13th day.—I observed four well-marked branchial arches springing from their centre, the hyoid bone; and in addition

to the three before seen, a fourth branchial artery. These four, with the primitive arch, complete the normal number of five arterial arches. As the first branchial artery, the second arterial arch, increases in size, the first arch rapidly diminishes. The subsequent changes, noticed as long as they could be seen, were as follows:—The heart, by the diminished bulk of the yelk-bag, &c., becomes more central, the anterior chamber retains its old position, but the posterior, instead of being external, is now internal to the anterior. This change of position would appear to take place in some such way as this (Fig. 29):—By the rapid growth and development of structures near to the heart, closing in the præcordial area, the large veins become median to the axis of the body; the posterior chamber into which they enter is drawn after them, bending, we may imagine, round an axis *x*, *x*, inwards, whilst the prominent wall of the anterior chamber sinks down from *a* to a^x, so that the appearance of the heart as last seen was that of Fig. 28, where the arrows indicate the direction of the blood-current—*a*, the posterior, *b*, the anterior chamber. The course of the blood through the heart is seen to be remarkably serpentine.

I am disposed to look upon these heart cavities as follows:—(Fig. 22) the space in which *c* is placed, as the auricle; (Fig. 39) the space in which *a* is placed, as the pericardium; and the posterior and anterior chambers, as the ventricle, and bulbus arteriosus.

In the branchial system of vessels a most singular change takes place, whereby the direction of the blood-current in a portion of the main vessel is reversed. Before this change occurs, the course of the blood is as follows (Fig. 30):—Starting from the heart it divides at *g*, into *k*, the branchial arteries which enter the aortic circle, and *g*, the primitive arterial trunk; the latter ascends to *i*, and there gives off supplies to the mouth, eye, and head, subsequently forming part of the aortic circle, and running downwards. After a time, fourteenth or fifteenth day, a small vessel (*l*) forms, running from the first branchial artery (*h*) to the primitive trunk. This is the venous or refluent branch of the first branchial artery. This last-named artery increases in size, and in a corresponding degree the primitive trunk not only ceases to enlarge, but becomes less. At last a slight ridge appears between the first and second vascular arches (at *g*); this ridge grows forward so as to press upon the primitive trunk. By means of this pressure the artery gradually dwindles away until it is obliterated from *g* to *i*. The course of the blood now is that of the adult circulation. It passes from the heart to the first (second, third, and fourth) branchial arteries, and enters the aortic circle. Part goes downwards, part goes upwards in a direction diametrically opposed to the former course, running from *m* to *i*, where it gives off *a*, the carotid, to supply the head; *d*, *e*, the orbits nasal, for the structures protecting the organs of



Development of ovum of Pike

sight and smell; and (the vessel from *i* to *g* being obliterated) ends its course in the refluent branch, *l*, of the first branchial artery. This vessel does not enter the branchial, but it terminates in a pseudo-branchial apparatus, or false gill, in the situation *l*. After supplying this apparatus the return blood from this false gill is collected into a vessel (*s*), which supplies the eye with blood, and hence is called the ophthalmic. Fig. 31 shows diagrammatically the remarkable change that takes place.

As circulation becomes well established in the branchiæ so that respiratory changes can take place to a considerable extent, the surface of the yelk-bag is less needed as a breathing apparatus; the channels appear to obtain walls of their own; they diminish in number; the yelk-bag becomes darker in consequence of numerous pigment cells becoming scattered over its surface, and lessens in size, the vessels doubtless becoming cutaneous veins, and entering the large or cardinal vein, which empties itself into the auricular sinus.

In order to protect the delicate structures of the gill from external injury, a movable covering or flap is placed over it: this is called the operculum (the dark line commencing at *h*, Fig. 32, shows the outline). This structure is continually in movement, flapping to and fro; and by means of this movement the water which is taken into the mouth is, when the mouth is closed, driven through the branchial interspaces. The operculum at first is transparent, and covers the branchial and præcordial spaces and the auricular sinus completely. The to-and-fro movement takes place twenty-five times in a minute, whilst the beats of the heart are 100. It is interesting to notice that the ratio of inspiratory and cardiac movements is the same as that of the human subject. In the case of man, the respiratory act occurs eighteen times per minute, and the cardiac movement seventy-two times, or four times as often, just as we find it in the fish. At the edge of the firm operculum is a transparent, thin, structureless membrane, which also moves to and fro with each respiratory effort, so that the edge of it describes a curve of a quarter of a circle: this is the branchiostegous membrane. Behind this, and indeed touched by it, is the pectoral fin (*a*, Fig. 33, which is a view from the back of the fish; it projects outwards). This fin is in a state of constant and rapid tremulous motion. The Os Hyoides (*m*, Fig. 32), with its attached branchial arches, moves at a joint seen at *l*. In the first place the mouth is opened, and water is taken into its cavity; at the same time, the hyoid bone, with its attached structures, including the operculum, moves downwards, as it necessarily must do when the lower lip is depressed; and the operculum opens widely. The mouth then closes; by this means the hyoid bone is drawn upwards, the cavity of the mouth is lessened, and part of the water escapes through the gills, aërating

the blood in its passage: lastly, the operculum closes, expelling most of the remainder. To support the delicate branchiostegous membrane, four bony processes are given off from the Os Hyoides. The blood-currents through the gills are next subdivided and broken up into an innumerable series of small vascular loops, by which means the blood is more thoroughly exposed to the purifying action of the water. It is only the commencement of this development which can be seen by the microscope, as pigment cells grow rapidly and obscure the parts beneath. The first step is the budding of the branchial arch into a set of tubercles, as at *a*, Fig. 35. These tubercles support a set of small vessels or villi, little vascular loops, which spring from the branchial artery, and transmit the blood-corpuscles in single file. The tubercles increase in size, and form a broadish leaf-like structure, of which there are a great number, springing from each arch. These leaflets support the subdivisions of the branchial artery: along the edge of each leaflet the artery is split up into many capillary vessels; these coalesce to form a vein containing aërated blood. The branchial artery divides lengthwise (Fig. 37) into artery and vein, the former tapering from the heart extremity to the aortic one, and giving off continually a branch to each leaflet as it passes along the branchial arch, the vein being parallel with it, but tapering in the other direction, being smallest where the artery is largest, and becoming larger as it receives the coalesced capillaries and advances past each leaflet to the aortic circle. Fig. 35: *a*, the leaflets as they are seen at first (Fig. 36, *a*, being another view); *b*, the villi, as first seen; *c*, the two together; *d*, pectoral fin; *e*, the intestine; *f*, liver; *g*, the yelk-ball, much shrunk by absorption of the vitellus. Fig. 36, *b*, *c*, *d*, the capillary loops; Fig. 37, diagram of *a*, the branchial artery; *b*, the branchial vein, with the intervening capillaries. The first villi were seen about the 28th April, 15th day. They then showed, as simple loops, the blood discs ascending, curling round, and descending. On the 30th the loop appeared spread out, almost circularly, and was bent, and sometimes twisted on itself (*c*, *d*, 36). They were increasing in length, and were beginning to subdivide, as seen at *b*, 33. Pulsation was evident in the loop. After this period the rapid increase of pigment prevented further observations on this point. On the 27th, in the auditory capsule, I observed three semicircular canals (Fig. 38), and an ampulla (*a*), into the dilated extremity of which two ends of one and one end of a second may be seen to enter. At the base of the ampulla is an otolith. The relations of the other otolith and the other terminations of the canals cannot be made out.

This brief abstract being now concluded, I have only to recapitulate the chief points observed by me.

The blood-corpuscles flow to the heart before the heart has

commenced to beat: the flow is therefore independent of the heart's action at this period.

The embryo is nourished by the vitellus contained in its yelk-bag until the time when the mouth is open and prey can be caught.

The heart was observed to beat before blood-corpuscles were within its cavity, showing that its contractions at that time at least did not depend on the stimulus afforded by the blood-corpuscles.

The respiratory changes in the blood were effected, in the first place, in the veins on the surface of the yelk-bag, and respiration took place at first before the blood reached the heart. This is the permanent condition amongst the Mollusca. After a time, the partial absorption of the yelk rendering the exposing surface less, and the increased size of the fish, demand more extensive methods of aërating the blood. This is attained by the formation of the gills; and then the respiratory changes occur *after* the blood has passed through the heart.

In Mammals, after birth, and in birds and reptiles after extrusion from the egg, a complete change in the course of circulation and in the manner of respiration necessarily takes place. This does not occur in the case of the fish: the circulation and respiration are the same after as before extrusion from the egg; that is, so far as any immediate change is concerned.

The blood-vessels are laid out independently of the heart; they do not grow out from it like the branches of a tree, but are formed in their several localities, and are afterwards united to each other, and thus to the centre of circulation.

A remarkable change takes place in the system of blood-vessels, whereby the direction of the current is reversed in a main vessel by the obliteration of its origin—a somewhat parallel but not analogous case to the obliteration of the *ductus arteriosus* in the Mammal, and the diversion of the blood-current into another channel.

In other respects the adult condition of the circulation appears to be the same as that gradually forming in the course of development of the embryo.

IV.—*The Anatomical Relations of the Ciliary Muscle in Birds. I. In the Green-breasted Pheasant.*

By Henry Lawson, M.D., F.R.M.S., Lecturer on Histology in St. Mary's Hospital.

Plate XXX. (lower half).

Some years since, while working at the physiological problem of the accommodation-power of the eye, I was led to examine the anatomical relations of the ciliary muscle. The first specimens on which I made my observations were the eyes of mammals. But the results were extremely unsatisfactory, from the circumstance that in the mammalian eye the muscle is composed of tissue of the non-striated class. Many histologists tell us that the recognition of this sort of muscular structure is easy enough; and this is true within certain limits. It is not difficult to say that a given mass of tissue is non-striated muscular tissue. But when we are required to define within exact limits the distribution of this piece of tissue, we come to a very complex task. The fact is that the non-striated muscular fibre and the connective-tissue fibre pure and simple, are so very like each other in appearance, that when they come into connection with each other, as they must in the case of the mammalian ciliary muscle, it is next to impossible to say where the one commences or the other ends.

To obviate this difficulty, I turned my attention to birds,

EXPLANATION OF FIGURES.

The following letters refer in all the figures to the same structures, respectively:—*Co.*, cornea; *ci.*, ciliary muscle; *scl.*, sclerotic; *ch.*, choroid; *c. t.*, connective tissue (loose); *sh.*, sheath.

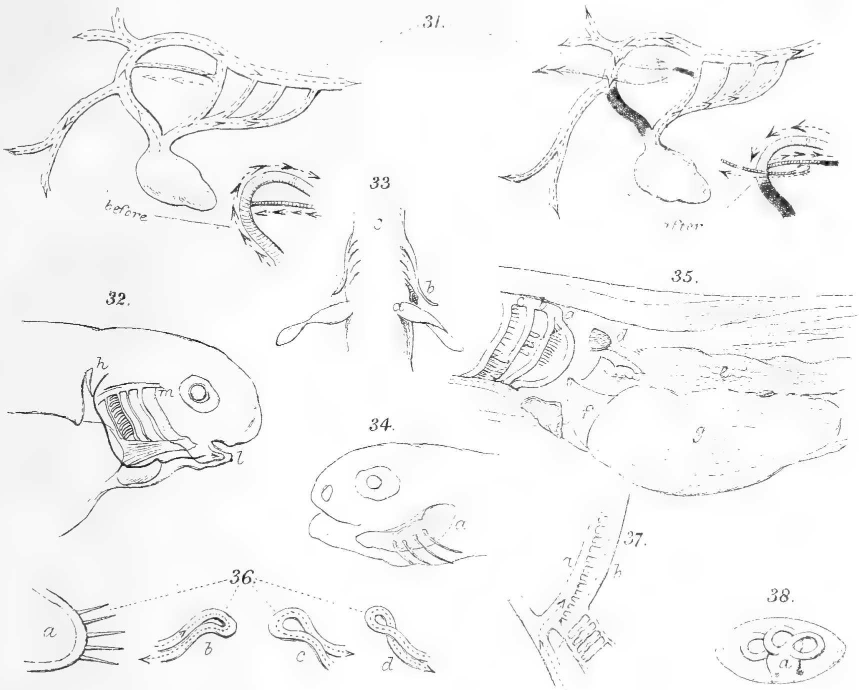
Fig. 1 shows the relation of the parts as shown under a low power (2 inch). Here the whole muscle is seen in pear-shaped section, and connected with the choroid by loose connective fibres at the border of the iris, and more strongly with the choroid behind.

„ 2 shows part of the section under a higher power ($\frac{1}{5}$ inch). The connective tissue character of the connection with iris is well seen, also the manner in which the fibres of the ciliary muscle pass forwards and become inserted in the sheath.

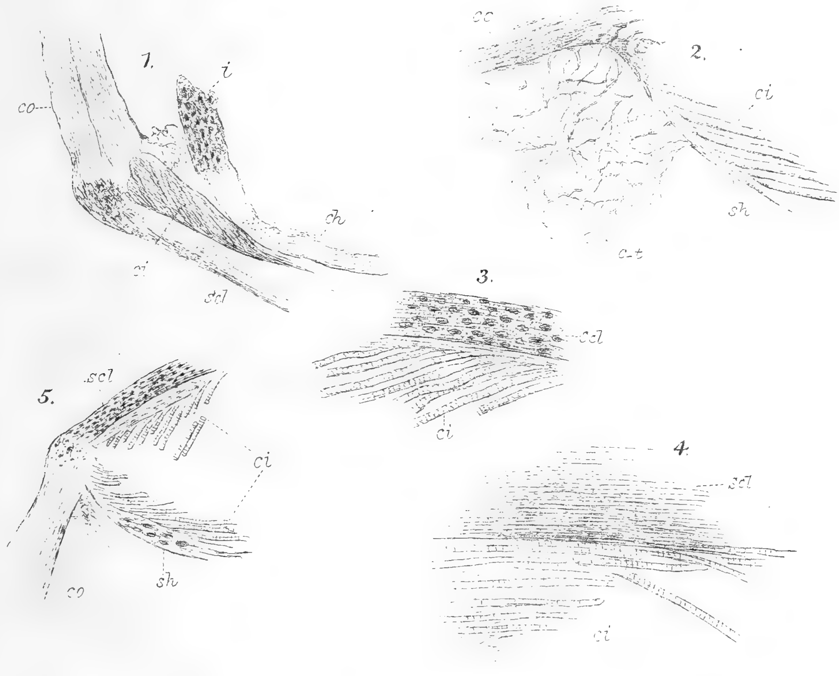
„ 3, also seen under $\frac{1}{5}$ inch, shows the sclerotic with its irregular-shaped pigment cells, and the fibres of the ciliary muscle, arising from the sclerotic, and streaming obliquely forwards and inwards.

„ 4, also seen under $\frac{1}{5}$ inch, shows the posterior extremity of ciliary muscle, and its relations to sclerotic and choroid. The latter having been torn away from the sclerotic, has left the ends of the fibres which had passed into the choroid, and by its removal have been ruptured.

„ 5, seen under $\frac{2}{3}$ inch. In this specimen the fibre was ruptured by drawing the sheath towards the centre of the eye, and pushing sclerotic in the opposite direction. The general course of the muscular fibres is very clearly seen, and the loose suspensory fibres of the iris are also shown.



E. B. Truman, del.



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Tuffen West, sc.

W. West imp.

Development of Pike ________ Relations of Ciliary muscle

where, as Crampton and others had pointed out, the ciliary muscle being distinctly striated, its beginning and end may be tolerably easily made out. It was in the 'Ophthalmic Review' (for, I think, the year 1865) that, in a paper objecting to Helmholtz's and Donders' notions of the cause of accommodation, I first published my remarks on the relations of the ciliary muscle: the eye of the ostrich having been taken as the example. The subject, however, has not received the attention it deserves from physiologists; and with a view to show that at least in birds, accommodation must be effected in a totally different manner from that proposed by Donders, I am led to bring the question once more under the notice of histologists. I propose from time to time, as I may have leisure, and as the Zoological Society may be able to furnish me with "birds' eyes," to describe the relations of this remarkable muscle in various birds, and first in the green-breasted pheasant, the eyes of which were kindly placed at my disposal by Dr. James Murie.

The description of the ciliary muscle in most of the text-books is, so far as it applies to birds, extremely misleading and inaccurate. It is generally described, both for man and birds, as a ring of muscular or fibrous structure extending all round the eye at the line of union of the sclerotic and cornea. But in birds it is really much more than this.

If we take only the bird which forms the subject of this note, we find that the ciliary muscle is much more than a mere ring. It is in some measure almost a distinct coat. It may be described as a zone or belt of muscular tissue (holding much the same sort of proportion to the orb that the Tropic of Cancer does to the globe), whose fibres run forwards to the line of junction of the cornea and sclerotic, and extend backwards between the sclerotic and choroid for some lines. In section made along the long axis of the eye, the ciliary muscle would have an irregular pear-shape, the head of the pear being at the sclerotico-corneal junction, and the stalk some lines behind and between the sclerotic and cornea. The fibres are broad and somewhat flat, of the usual faintly-yellow colour (caused by steeping structure in chromic acid), and very beautifully striated, and they pass in a regular stream from behind forwards, and from without obliquely inwards, till they end generally in the sclerotico-corneal junction. All the fibres do not pass into this line of junction. The muscle is provided with a very tough and dense sheath of connective tissue, which is so loaded with irregular pigment-cells as to render the definition of the fibres at first rather difficult. But this sheath is more than a mere envelope. It increases in thickness and toughness at the sclerotico-corneal junction, and along the anterior half of its length (along the pear-shaped part) it gives insertion to the anterior extremity of many of the muscular fibres which are tra-

velling toward the sclerotico-corneal junction. The insertion then of all the fibres of the ciliary muscle may be said to be the sheath of the muscle at its anterior extremity and the inner lamina of the cornea.

What is the origin of this muscle? In regard to this, if the muscle of this bird examined in the present instance displays the same relations as that of the ostrich, I have to correct a mis-statement made in my former paper.* The origin of the fibres is not *absolutely* confined to the inside of the sclerotic. Some few of them may be traced into the choroid coat. These are a few of the most posterior fibres; and my reason for assuming that they have an origin in the choroid is, that when the latter is torn away the fibres are set free, and present the usual sharply broken extremities.

The plan of manipulation I have adopted in making the observations which have led to these conclusions is this:—The eye is first divided into two parts—from above downwards, and in the transverse plane. The posterior half falls away with the vitreous and lens, leaving the cornea, part of the sclerotic, the iris, part of the choroid, and the remainder of the ciliary processes. With a pair of scissors then this hemisphere is cut into halves. Then with a Valentin's knife I take a number of extremely delicate sections, at right angles to the internal surface of the eye, and in the antero-posterior direction. By this means I obtain specimens showing cornea, sclerotic, choroid, iris, and ciliary muscle.

Having placed one of these sections in glycerine, a needle is used—not to "tease out," but merely to prevent the falling together of the several parts. Under a low power, and with Mr. Collins' new dissecting microscope, this can readily be done. It is then seen that the muscle is of the form I have described, and that the choroid is united to the sclerotic at two points. One of these points—the anterior one, on a level with the iris—is, as shown in the drawing, merely a feeble union, maintained by a few fine fibres of elastic connective tissue. The other is a muscular union, is more posterior—being, in fact, at the hinder extremity of the ciliary muscle—and is formed, so far as I can see, by the passage of a few muscular fibres into the soft substance of the choroid. At these two points, then, there is connection of the muscle with the choroid. The anterior one is merely a loose attachment, and a mere stroke of the needle severs it without injuring the muscle or the choroid; the other is more decided, and when it is broken the two or three muscular fibres involved in it present broken extremities.

All through the rest of its course the muscle is distinct; its outer side firmly and inseparably blended with the sclerotic, and its inner one bounded by its special sheath. This is nearly all that I have got to say as to the position of this muscle. My view may

* 'Ophthal. Review.'

be wrong. I don't think it is. But supposing it right, I would ask, What effect can this muscle have on the consistence of the lens, from which it is so distant? How can it advance the lens through the action on choroid, to which its attachment is so far posterior to the lens? and lastly, What can be the effect of the contraction of so important a muscular structure but to bend in the border of the cornea, and thus increase the curvature of the object-glass of the eye? Its origin—the sclerotic—is unyielding; its insertion—the cornea—is. The liquid of the eye resists the inward pressure of the cornea, and driving its central part out, still more increases the curvature. Lastly, in the elastic lamina of the cornea do we not see the antagonist of this powerful muscle. Birds must necessarily possess greater power of focal accommodation than man, but why should the mechanism by which that accommodation is obtained be so different from that of man as the views of Helmholtz would lead us to suppose, if we believe the ciliary muscle of birds to operate as I have suggested?

NEW BOOKS, WITH SHORT NOTICES.

Recherches sur l'embryogénie des Crustacés. I. Observations sur le développement de l'Asellus aquaticus. Par Edouard Van Beneden, 1869.—Although the valuable memoir which M. Van Beneden has been good enough to send us is not a book in the publishers' sense of the word, it is a work of so much importance that it justifies our noticing it under the head of Reviews. It is the reprint of a communication recently made to the Royal Academy of Belgium on an interesting species of fresh-water crustacean, and it expresses results of the highest value, especially in relation to the curious researches of Fritz Müller and others in reference to those Nauplius forms which have so singular a bearing on Mr. Darwin's views. M. Van Beneden first sketches briefly the labours of those who have preceded him in the field, and he does so in that appreciative and kindly manner which is so characteristic of the genuine lover of scientific research.

Fritz Müller, in his 'Für Darwin,' a book some time since noticed in these columns, made known, under the name of larval membrane, *larvenhaut*, a structureless membrane, which in the Isopoda, and especially in *Ligia*, is formed round the embryo in the first stages of its development. This cuticular layer has the shape of an elongated sac, without lateral processes in the form of appendages, and should be considered, says the author, not as a dependent membrane of the ovum, but as the residue of the first embryonic moult. Now, M. Dohrn has recognized that there is found round the embryo of the young *Asellus* just such a membrane as that which Fritz Müller has described in *Ligia* and others. M. Sars has also observed this, and has seen its relations to the antennæ, which had escaped M. Dohrn, and which is a morphological fact of great import. MM. Dohrn and Sars consider that the egg, at the moment it passes into the incubating pouch, is surrounded by two membranes, the outer of which represents the chorion, and the inner of which is a vitelline membrane. M. Dohrn has not tried to determine its significance, and he has simply termed the inner egg-membrane *innere Eihaut.*

But the author has satisfied himself that at the moment of the egg's passing into the incubating pouch it is surrounded by a single membrane, which is directly applied to the vitellus. Soon, however, this separates, and leaves between it and the vitellus a transparent liquid. The single envelope on the recently-deposited ovum is what is generally styled the chorion. The other or inner membrane forms itself in the ordinary course of development after the egg has remained for some hours in the incubating pouch. What is the value and import of this envelope? Is it part of the ovum, or is it rather an embryonic formation and the remnant of an embryonic moult which precedes the Nauplius moult?

A number of questions remain to be decided:—(1) Is the ovum of *Asellus* really covered at the moment of deposition by two envelopes, as MM. Dohrn and Sars allege? (2) What is the morphological significance attaching to the inner membrane, which according to M. Sars is a vitelline membrane? (3) Is M. Dohrn correct in comparing the membrane which he calls *Larvenhaut* in Asellus with the larval membrane of *Ligia?* It is to the consideration of these three problems that M. Van Beneden devotes his attention in the memoir before us. He goes into the details of the embryology of Asellus which bear on the point; traces out the whole early development of the species; and illustrates it by four plates containing several well-drawn representations of the egg and larva in different phases; and finally concludes by laying down the following propositions:—(1) The ovarian egg, at the time of deposition, consists of only one membrane, the chorion. (2) This membrane remains for some considerable period the sole membrane of the egg. (3) The membrane, which both MM. Sars and Dohrn associate with the ovum, is really an embryonic membrane. (4) The study of the inferior crustacea, and especially of Anchorellæ and Lerneopodæ, demonstrates that in these Lerneæ the embryo undergoes three moults even while in the egg: a Blastodermic moult, a Nauplian moult, and a Cyclopean or Zoëan moult. That each of these moults consists in the loss of a cuticular membrane, having the form which the embryo has at the time the membrane is formed. The first embryonic membrane of Asellus is a Blastodermic cuticle, and subsequently there is formed a Nauplian cuticle which corresponds to the larval membrane of *Ligia.* M. Van Beneden's memoir is one which must be carefully studied by every student of Embryology.

PROGRESS OF MICROSCOPICAL SCIENCE.

The Development of the Chœtopoda.—Under this title a very valuable memoir has been written jointly by Professor Claparède and Mecznikow, in the last number of Siebold and Kölliker's *Zeitschrift.* It is illustrated by a great number (upwards of a hundred) beautifully-drawn coloured figures, and traces the stages of development in the typical members of the family of this group. Each species selected is dealt with separately and completely, and the whole memoir is one of the fullest published on the subject.

The Anatomy of the Bed-bug.—The structure of *Cimex lactularius* is very fully described in another paper in Siebold's *Zeitschrift* by Herr Professor Landois. This is a continuation of a paper published some time since in this Journal by the same author. In this part Dr. Landois treats of the respiratory, reproductive, and muscular systems.

His account is partly based on the researches of those who have preceded him, and in great part on his own observations. The plates accompanying this article are two in number, and are carefully drawn. His account of the reproductive system and of the arrangement of the muscles is particularly good, especially the latter. He describes very minutely the attachment of the various muscles which are employed in working the proboscis. The paper should be consulted by those Fellows of the Royal Microscopical Society who wish to work out this subject.—See *Zeitschrift für Wissenschaftliche Zoologic*, 19 Band., 2^na^ Heft, 1869.

The Oral Apparatus of Oxyuris.—Herr J. H. L. Flögel publishes a brief but good contribution to the anatomy of the mouth of this nematoid and its congeners. His illustrations are in some cases merely diagrammatic, but in other cases they represent different front and profile views of the head. The lips and their peculiar papillæ are especially the subject of this paper. The author employed immersive objectives.—*Ibid.*

The Reproduction of Siphonophora.—The number of Siebold's journal already referred to, and which is rich in histological matter, contains also an interesting paper which is hardly microscopic, though nearly so. The author, Dr. Alex. Pagenstecher, of Heidelberg, describes a new and peculiar mode of reproduction in this cœlenterate.

Histology of the Lower Animals.—Under this title Herr Fritz Ratzel has commenced, in the last number of the *Zeitschrift für Zoologie*, the first of a series of papers, which he proposes to make a histological account of all the lower animals. The present communication deals with the muscular system of annelids; but is not at all as comprehensive as the memoir published on the muscular tissue of mollusks, by Franz Boll, and which appeared in a recent supplement to *Schultze's Archiv*. We notice too that the author does not refer to the labours of some English zoologists as he ought to do. This paper is followed by a very short one on the muscular system of Nematoides, by Herr Anton Schneider.

Acanthocystis Viridis.—Dr. H. Grenacher makes some observations on this species in the same number of Siebold's *Zeitschrift* above referred to.

Intermediate Forms between Worms and Crustacea.—Some years since M. Dujardin called attention in the *Annales des Sciences* (1851), to a small marine form which seemed to connect the Crustacea and annelids. This creature *Echinoderes* has been very minutely described and figured in a memoir published by Herr Dr. Richard Greef, of Bonn. The author gives an account of both the general morphology and internal anatomy of various species of the genus. The subject has an interest in connection with Mr. Darwin's views.—*Vide* Wiegmann's *Archiv für Naturgeschichte.* 1 Heft. 1 Band. 1869.

The Pollen Grains of Onagraceæ Cucurbitaceæ and Corylaceæ.—To those who desire an easy and interesting subject for microscopic work, the paper on the above subject, by Herr C. W. Luerssen, will afford

ample suggestions. The author takes up the question whether the pollen grains of those families consist of a single cell or of more than one. The illustrations are very numerous, and altogether the paper shows how much elaborate research may be carried out in so limited a subject.—*Jahrbuch für Wissenschaftliche Botanik*, 1869.

The Natural History and Development of the Ustilagineæ.—This is a memoir, copiously illustrated and extending over 100 pages, and fully dealing with a very extensive branch of fungology. The author is Dr. A. Fischer von Waldheim. We wish the paper could be reproduced in full in our language.

The Microscopical Structure of the Convolutions of the Brain.—The 'Journal of Mental Science' gives the following summary of Mr. Lockhart Clarke's latest researches on this subject. The summary was, we believe, prepared by Mr. Clarke for the recent second edition of Dr. Maudsley's treatise on the Physiology of the Mind.

In the human brain most of the convolutions, when properly examined, may be seen to consist of at least *seven* distinct and concentric layers of nervous substance, which are alternately paler and darker from the circumference to the centre. The laminated structure is most strongly marked at the extremity of the *posterior* lobe. In this situation all the nerve-cells are *small*, but differ considerably in shape, and are much more abundant in some layers than in others. In the superficial layer, which is pale, they are round, oval, fusiform, and angular, but not numerous. The second and darker layer is densely crowded with cells of a similar kind, in company with others that are *pyriform* and *pyramidal*, and lie with their tapering ends either toward the surface or parallel with it, in connection with fibres which run in corresponding directions. The *broader* ends of the pyramidal cells give off two, three, four, or more processes, which run partly toward the central white axis of the convolution and in part horizontally along the plane of the layer, to be continuous, like those at the opposite ends of the cells, with nerve-fibres running in different directions.

The third layer is of a much paler colour. It is crossed, however, at right angles by narrow and elongated groups of small cells and nuclei of the same general appearance as those of the preceding layer. These groups are separated from each other by bundles of fibres radiating toward the surface from the central white axis of the convolution, and, together with them, form a beautiful fanlike structure.

The fourth layer also contains elongated groups of small cells and nuclei, radiating at right angles to its plane; but the groups are broader, more regular, and, together with the bundles of fibres between them, present a more distinctly fanlike arrangement.

The fifth layer is again paler and somewhat white. It contains, however, cells and nuclei which have a general resemblance to those of the preceding layers, but they exhibit only a faintly radiating arrangement.

The sixth and most internal layer is reddish grey. It not only abounds with cells like those already described, but contains others

that are *rather larger.* It is only here and there that the cells are collected into elongated groups which give the appearance of radiations. On its under-side it gradually blends with the central white axis of the convolution, into which its cells are scattered for some distance.

The seventh layer is this central white stem or axis of the convolution. On every side it gives off bundles of fibres, which diverge in all directions, and in a fanlike manner, toward the surface through the several *grey* layers. As they pass between the elongated and radiating groups of cells in the *inner* grey layers, some of them become continuous with the processes of the cells in the same section or plane, but others bend round and run *horizontally*, both in a transverse and longitudinal direction (in reference to the course of the entire convolution), and with various degrees of obliquity. While the *bundles* themselves are by this means reduced in size, their component *fibres* become finer in proportion as they traverse the layers toward the surface, in consequence, *apparently*, of branches which they give off to be connected with cells in their course. Those which reach the outer grey layer are reduced to the finest dimensions, and form a close network with which the nuclei and cells are in connection.

Besides these fibres, which *diverge* from the central white axis of the convolution, another set, springing from the same source, converge, or rather curve inward from opposite sides, to form arches along some of the grey layers. These arciform fibres run in different planes—transversely, obliquely, and longitudinally—and appear to be partly continuous with those of the *divergent* set which bend round, as already stated, to follow a similar course. All these fibres establish an infinite number of communications in every direction between different parts of each convolution, between different convolutions, and between these and the central white substance.

The other convolutions of the cerebral hemispheres differ from those at the *extremities of the posterior lobes*, not only by the comparative faintness of their several layers, but also by the appearance of some of their cells. We have already seen that, at the extremity of the *posterior* lobe, the cells of ALL the layers are *small*, and of nearly uniform size, the inner layer only containing some that are a little larger. But, on proceeding forward from this point, the convolutions are found to contain a number of cells of a *much larger kind.* A section, for instance, taken from a convolution at the vertex, contains a number of *large*, triangular, oval, and pyramidal cells, scattered at various intervals through the two inner bands of arciform fibres and the grey layer between them, in company with a multitude of smaller cells which differ but little from those at the extremity of the posterior lobe. The pyramidal cells are very peculiar. Their bases are quadrangular, directed toward the central white substance, and each gives off four or more processes which run partly toward the centre, to be continuous with fibres radiating from the central white axis, and partly parallel with the surface of the convolution, to be continuous with *arciform* fibres. The processes frequently subdivide into minute branches, which form part of the network between them. The opposite

end of the cell tapers gradually into a straight process, which runs directly toward the surface of the convolution, and may be traced to a surprising distance, giving off minute branches in its course, and becoming lost, like the others, in the surrounding network. Many of these cells, as well as others of a triangular, oval, and pyriform shape, are as large as those in the anterior grey substance of the spinal cord.

In other convolutions the vesicular structure is again somewhat modified. Thus, in the surface convolution of the great longitudinal fissure, on a level with the *anterior* extremity of the corpus callosum, and therefore corresponding to what is called the superior frontal convolution, all the three inner layers of grey substance are *thronged* with pyramidal, triangular, and oval cells of considerable size, and in much greater number than in the situation last mentioned. Between these, as usual, is a multitude of nuclei and smaller cells. The inner orbital convolution, situated on the outer side of the olfactory bulb, contains a vast multitude of pyriform, pyramidal, and triangular cells, arranged in very regular order, but none that are so large as many of those found in the convolutions at the vertex. Again, in the *insula*, or island of Reil, which overlies the extra-ventricular portion of the corpus striatum, a great number of the cells are somewhat larger, and the general aspect of the tissue is rather different. A further variety is presented by the *temporo-sphenoidal* lobe, which covers the *insula* and is continuous with it; for, while in the superficial and deep layers the cells are rather small, the middle layer is crowded with pyramidal and oval cells of considerable and rather uniform size. But not only in different convolutions does the structure assume, to a greater or less extent, a variety of modifications, but even different parts of the same convolution may vary with regard either to the arrangement or the relative size of their cells.

Between the cells of the convolutions in man and those of the *ape-tribe* I could not perceive any difference whatever; but they certainly differ in some respects from those of the larger mammalia—from those, for instance, of the ox, sheep, or cat.

The Structure of the Human Blood-corpuscle.—As far back as May, 1868, Professor Freer, of Rush Medical College, U.S., asserted that human blood-corpuscles were not, as heretofore supposed, simply bi-concave discs; but that, on the contrary, there may be seen (by the use of Wale's illuminator) a nipple-like eminence in the centre of the concavity of each well-formed disc. This papillary eminence is about $\frac{1}{10000}$ of an inch in diameter at its base; consequently, he arrays himself against the expressed opinion of physiologists and microscopic anatomists as set forth in standard works, *to wit*, that the human blood is non-nucleated. Continued investigation on this subject since the first article was published, has confirmed the announcement then made, and now he illustrates his discovery by two diagrams—one representing corpuscles of human blood, the other corpuscles of a frog—both of which exhibit these eminences. All of the research upon which his present convictions are based has been prosecuted by the use of *reflected light* instead of transmitted light, by which most examinations of blood-corpuscles have been made heretofore. Cor-

puscles found in defibrinated blood are, he says, the best for observation.—*Vide* 'New York Medical Record,' August 16th.

Dr. Carpenter's Deep-sea Expedition.—At the meeting of the British Association a letter was read by the Rev. A. M. Norman from Professor Wyville Thomson on the "Successful Dredging of H.M.S. 'Porcupine' in 2435 fathoms." This is nearly the height of Mont Blanc. It must be understood that dredging is a very different thing from sounding. The first dredge brought up 1½ cwt. of ooze, the second 2 cwt., from this great depth. The bottom temperature was 30°. The sun's heat extended downwards 20 fathoms; that of the Gulf-stream 500 fathoms; after that the temperature sank generally at the rate of two-tenths of a degree for every 200 fathoms. Not only was animal life abundant at the great depth of nearly 2500 fathoms, but many new forms were added to science, and several related to the British fauna. The chemical condition of the water at great depths showed that it was strongly impregnated with organic matter, which accounted for the food provided for the animals at the bottom of the sea. The dredging demonstrated that there were living creatures now at the bottom of the sea precisely similar to the fossils of the chalk.

Microscopic Examination of Obsidian.—Mr. W. C. Roberts, F.C.S., F.G.S., gave an account at the Exeter meeting of his application of the microscope to the examination of specimens of obsidian from Java. The paper was a statement of the results of the examination of a substance that, from the indefinite character of its composition, partakes of the nature of a rock rather than that of a mineral. The specimen of obsidian was from Java, originally in the cabinet of Bernard Woodward, Esq., but the label does not give the exact locality. It appeared to differ much from that, also from Java, now in the British Museum. The specific gravity of the specimen was 2·35; in thin sections it is perfectly transparent. Mr. Roberts gave an analysis of its composition, and said that it may be easily cut into thin sections, and by the aid of a low power, say 200 diameters, at least three distinct minerals (beautifully crystallized) may be distinguished, diagrams of which were produced with the specimen.

Photographs of Nobert's Lines.—The recently-published 'Transactions of the Philadelphia Academy of Natural Science' gives the following account of the presentation of Drs. Curtis and Woodward's photographs of Nobert's lines, and as the photographs are also in the library of the Royal Microscopical Society, the observations may be of interest to our readers:—"The bands were very beautifully photographed, showing up to the sixteenth perfect lines that can be counted through the whole width. Their instruments failing to resolve, or rather, to photograph the four finer bands, sixteen, seventeen, eighteen, and nineteen, Dr. Woodward infers that the last four bands have not been resolved. Mr. Stodder remarked that in his opinion the claim to have resolved the finer bands, advanced by Mr. Greenleaf and himself, was not disproved by this failure to photograph them. The condition of the microscope for photographing (without an eye-piece)

is so different from its condition for vision, that he considered the failure to photograph lines of such exceeding delicacy no proof that the lines could not have been seen, and more than that, that the failure of one operator to photograph with a certain instrument is not to be accepted as a proof that another observer with another instrument and other manipulations failed to see these lines. Mr. R. C. Greenleaf showed a specimen of *Amphipleura pellucida*, mounted dry, on which he claimed to show the markings. As this has been one of the most difficult of the diatoms to resolve, and perhaps the one about the resolving of which there has been the most dispute, Mr. Greenleaf proposed leaving the matter open for further examination and discussion. Dr. Rufus King Browne, of New York, being present, spoke of the difficulty of perfectly resolving the markings on this form; he considered the markings *as granules* or *tubercles*, which appear as lines or *puncta*, according to the light thrown upon them, and that the markings were not as fine or close as claimed by microscopists." This observation so thoroughly confirms the results obtained by our President (the Rev. J. B. Reade, F.R.S.) and Mr. Wenham, that it deserves attention at the present time.

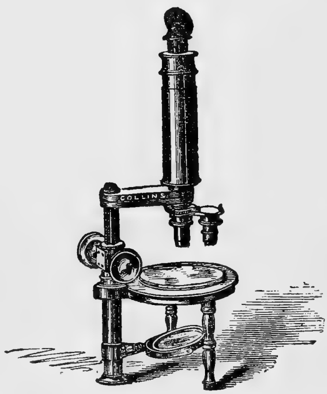
A Peculiar Minute Thread-worm infesting the Brain of the Snake-bird (*Plotus anhinga*).—Dr. Jeffries Wyman, the well-known American physiologist, has described and figured a minute parasite of the Nematoid group, which he has found in great multitudes in the brain of the Snake-bird of East Florida. The parasites were in all cases found coiled up on the back of the cerebellum, just behind the cerebral lobes; in one case there were so many of them that they made " a deep indentation of the cerebellum." The *female* is readily distinguished by being much larger than the male, measures 65 millimètres in length, and when fully distended with eggs has a diameter of 0·5 millimètre. The mouth is terminal, without lips or papillæ, the intestine passes in a straight direction to the opposite end of the body, and if it opens at all does so at the point of it, though the opening itself was not distinctly seen. Several loops of the oviduct are easily observed through the integuments, and one much larger than the rest can be seen at the hinder part of the body. The genital pore was not found, but is probably in the middle portion of the body, as near the two ends only loops of the oviduct are seen, and these nowhere connected with the walls. The *male* is only about one-half the linear dimensions of the female, and the hinder portion of the body is always more closely coiled. The intestine has the same arrangement as in the female. Near the hinder end of the body, and on the concave side of the last half-coil, is a papilla from which in one case we saw the male organ protruded, having the form of a slightly recurved spine. The base of this was buried beneath the surface, and in close relation to the end of the spermatic tube. In almost every instance the oviducts were largely distended with ova in different stages of development, and with hatched young. The eggs are of an oval form, their long diameter being about 0·02 millimètre. Those least advanced contained simply granules, and others had the embryo roughly sketched by the arrangement of the whole mass of

granules in the form of a coiled cylinder of uniform diameter throughout, slightly rounded at the two ends, and invested with a thin membrane. It is while in this stage that the embryo leaves the egg, and vast numbers of them were seen without coverings, but still closely coiled. As they descend towards the lower part of the oviduct they begin to straighten themselves, and at the same time undergo a slight change of form. As the body uncoils one end enlarges, and the whole tapers regularly towards the hinder part, and forms an extremely elongated cone. When perfectly straight they measure about 0·15 millimètre in length. Dr. Wyman was unable to detect any internal organs, if such existed, at any stage of development observed; but, on the contrary, saw nothing but granules, filling the integuments as in the first formation of the embryo.

The Development of Brachiopoda.—This subject, to which so little attention has been paid, has been lately taken up by an American naturalist, Mr. E. S. Morse, who has shown by embryological observations the close relation which exists between Brachiopods and Polyzoa. The eggs were kidney-shaped, and resembled the statoblasts of Fredericella. No intermediate stages were seen between the eggs and the pear-shaped form. This stage recalled in general proportions Megerlia or Argiope in being transversely oval, in having the hinge-margin wide and straight, and in the large foramen. Between this stage and the next the shell elongates until we have a form remarkably like Lingula, having, like Lingula, a peduncle longer than the shell, by which it holds fast to the rock. It suggests also in its movements the nervously acting Pedicellina. In this and the several succeeding stages, the mouth points directly backward (forward of author's), or away from the peduncular end, and is surrounded by a few ciliated cirri, which forcibly recall certain Polyzoa. The stomach and intestine form a simple chamber, alternating in their contractions, and forcing the particles of food from one portion to the other. At this time also the brownish appearance of the walls of the stomach resembles the hepatic folds of the Polyzoa. In a more advanced stage, a fold is seen on each side of the stomach; from this fold the complicated liver of the adult is developed, first, by a few diverticular appendages. When the animal is about one-eighth of an inch in length, the lophophore begins to assume the horseshoe-shaped form of Pectinatella and other high Polyzoa. The mouth at this stage begins to turn towards the dorsal valve (ventral of author's), and as the central lobes of the lophophore begin to develop, the lateral arms are deflected. In these stages an epistome is very marked, and it was noticed that the end of the intestine was held to the mantle by attachment, as in the adult, reminding one of the *funiculus* in the *Phylactolæmata.* No traces of an anus were discovered, though many specimens were carefully examined under high powers for this purpose, the intestine of the adult being repeatedly ruptured under the compressor without showing any evidence of an anal aperture.—*American Naturalist,* Sept.

NOTES AND MEMORANDA.

A New Dissecting Microscope.—We have examined an instrument recently brought out by Mr. Chas. Collins, and which we think will be found very useful by those who dissect under the higher magnifying powers. It has (as seen in figure) a tripod foot, and a large glass stage which is movable, and can be replaced by a trough of gutta-percha or other material. The peculiarity of the instrument lies in the fact that Mr. Collins has adapted to the eye-piece a compound prism which acts as erector, and at the same time throws the rays from a vertical to a horizontal position, so that the head need not be stooped. We had thought that such an arrangement would have absorbed too much light, but we found dissection under the inch and two-inch extremity easy and comfortable.



New Dissecting Microscope.

The Rules of the Royal Microscopical Society.—In answer to N. N., we may mention that the Society has a very large collection of objects and microscopes, and an excellent library. Lectures are not delivered, but papers are read and published, as N. N. may see in this Journal. Our correspondent should communicate (giving his real name and address) with one of the Secretaries.

Mr. Ross's New Immersion Lenses.—Mr. Ross has just prepared a number of immersion lenses, which our readers will do well to examine. The working powers of the $\frac{1}{12}$th appear excellent. There is a decided improvement over the dry glass in definition, and there is vastly more light. It must be remarked, however, that this new immersion lens is not a cheap objective like any of those made by Nachet, Hartnack, or Merz. The cost of labour in these countries prevents the possibility of producing a cheap first-class immersion object-glass.

Meteorites under the Microscope.—Herr Tschermak and others on the Continent are investigating the structure of meteorites under the microscope. This is a new field for some of our workers in the Royal Microscopical Society.

Protoplasm, Life Force, and Matter.—Under this title a new work by Dr. Beale is announced to appear this month.

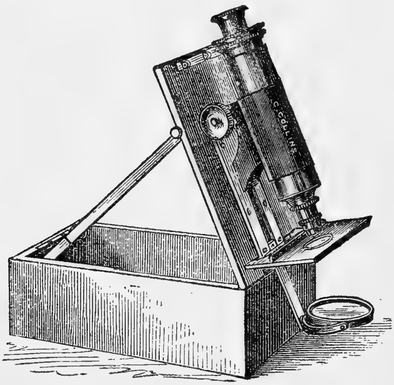
How to Work with the Microscope.—A fourth edition of Dr. Beale's book is, we believe, issued.

Country "Fellows" of the R.M.S.—A correspondent asks why country Fellows, who are seldom able to attend the meetings, and to whom the library offers little advantage, should have to pay the same entrance fee and subscription as town "Fellows?" The question is one for the Council to answer.

Plumules of Moths.—We hope to give the second part of Mr. Watson's paper, with illustrations, in our next Number.

A Handbook of British Fungi, which will include all known species, and will therefore deal with an important branch of microscopic research, is in preparation by Mr. M. C. Cooke, the well-known fungologist and foreign secretary to the Quekett Club. It will form one volume, small octavo, and will contain full descriptions of all known species of British fungi, with illustrations of the principal genera, and references to figures of the species. The price will be half-a-guinea to subscribers. The publication will be commenced as soon as the names of sufficient subscribers have been received to warrant the undertaking. Communications should be addressed to Mr. M. C. Cooke, 2, Junction Villas, Upper Holloway, London, N.

Mr. Collins's Portable Microscope.—Mr. Collins has constructed a portable microscope which is especially intended for those who purchase some of his larger instruments. When packed it forms an oblong mahogany box, about 6 inches long by 3 inches wide, and $2\frac{1}{2}$ high. It may easily be carried in the great-coat pocket. It is difficult to explain its construction, which is partly shown in the adjacent figure. The microscope body is attached to the inner side of the cover of the case. This cover, on being lifted up, is made to rotate on a central pivot, so that its inside is loosened out. The degree of slope is obtained by an oblique bar, which slides in a second one, and which supports the lid and can be clamped at any angle. The stage is small, and the mirror draws out from beneath it. The objectives and eye-piece are those of this maker's other instruments. We have done some work with this instrument, and found it very handy, in the absence of our larger microscope.



Collins's Portable Microscope.

A New Manipulator, by J. Howard Hooper.—There can be few microscopists who have not longed for some more ready and exact method of manipulation under the compound microscope than is afforded by even the steadiest and most practised hand; and several instruments more or less complex have been devised and even patented for this purpose, but all have been constructed on the

plan of a movable tool. A little consideration will, however, show that to keep the point worked with in view it must be perfectly steady in the field of the objective, and, further, that in the stage and body movements of the modern microscope we have a most perfect apparatus for executing any kind of work by substituting motion of the object for that of the tool. This principle once adopted, it becomes comparatively easy to adapt instruments to the kind of work required, and I append descriptions of those I have myself employed, less that I regard them as the best practicable arrangement, than that, being easily constructed by any one at the cost of a few pence, they serve as a ready means of ascertaining the practical value of the system.

To the arm, or any flat part of the microscope between the coarse and fine adjustments, attach a stiff, square plate of metal, about $1\frac{1}{4}$ inch diagonally, by two binding screws working through slits in opposite corners, so as to permit the plate a horizontal motion of about $\frac{1}{8}$th of an inch. To this plate is soldered vertically a stout steel spring clip, readily made as follows:—Procure one of Lund's patent paper clips, sold by most stationers; heat it red hot, to destroy the temper; then, with a stout pair of scissors, cut the slit to the width of about $\frac{1}{5}$th of an inch, and retemper the tube.

Select some glass tube of a size to slide rather stiffly in this clip, draw it out at one end to about $\frac{1}{8}$th of an inch thickness, bend the thin part at an angle of 45°, and draw out so as to keep it at this thickness for half-an-inch, or rather more, and cut it off. Three or four of such tubes will be useful. Next take a common vaccine tube and draw it out in a spirit-lamp to the finest possible point.

Place one of the prepared tubes in the clip, first attaching this to the microscope, and set it so that the angular part of the tube points as nearly as you can guess to the field of the objective you intend to use. Measure as accurately as you can the distance of this end from the centre of the field, and having found it, measure the same distance on the vaccine tube from the fine end. At the point thus found apply a little sealing-wax round the vaccine tube, and having moderately heated the thin end of the other tube, insert the vaccine tube into it, when it will quickly become fixed in any position desired. When the tube is replaced in the clip, the point of the vaccine tube should admit of being brought into the centre of the field of the objective used. If it should not do so, the sealing-wax may be reheated, and the vaccine tube shifted as required. Minor corrections may be made by the sliding motion of the clip-holder.

You will thus have fixed in the field, and moving with it, a manipulator far more delicate and elastic than any needle or hair. However, either needle or hair may be used in the same way if desired. For dissection a thick needle beaten while red hot to a spatula end, well retempered, and ground to a very fine edge, will be a good form of knife.

It would be easy to adapt a forceps arrangement, if desired; but for most purposes the syringe I am about to describe will be preferable. The body of the syringe is constructed exactly as the manipulator above described, except that the point of the vaccine tube is broken

off so as to leave a tubular opening of the required fineness. The piston consists of a moderately fine screw, firmly inserted below into a sound cork shaped to fit the tube, and passing above through a circular nut working in a ring. This ring has soldered to it below a bit of metal tube large enough to let the screw pass freely through it, and fitting loosely into the upper end of the glass tube, to which it may be attached by sealing-wax in exactly the same way as the vaccine tube is to the other end. On turning the nut the piston will be raised or lowered as required. The syringe must be filled completely with water before use; it will then act with the utmost precision and delicacy. Any object selected is brought to the mouth by the stage movements, and on turning the nut is instantly sucked up, and can be as readily deposited wherever required. Where two needles are desired the second should be attached to the stage in the same way as the stage forceps.

PROCEEDINGS OF SOCIETIES.*

Royal Microscopical Society.

King's College, *September* 22, 1869.

The Society will hold its first meeting of the session on Wednesday evening, the 13th of October, at 8 p.m., when the following papers will be read:—"On Immersion Objectives and Nobert's Test-Plate," by Lieut.-Col. Woodward, U.S. army; "On High-power Definition, with illustrative examples," by G. W. Royston Pigott, M.D., F.R.A.S.; and Mr. Carruthers will give (*vivâ voce*) a communication "On Plants of the Coal-measures."

Walter W. Reeves,
Assist. Secretary.

Quekett Microscopical Club.†

At the ordinary meeting, held at University College, Aug. 27, 1869, Dr. R. Braithwaite, F.L.S., Vice-President, in the chair, three new members were elected. Several donations to the club were announced, and four gentlemen were proposed for membership. A paper by Mr. G. W. Hart, "On Oysters and Oyster Spat," was read by the secretary, in which the growth and development of the embryo oyster was described at length, and a number of interesting questions as to the mode of fertilization and reproduction were brought forward. The paper was illustrated by diagrams. Mr. B. T. Lowne made some observations upon the subject of the fertilization of the oyster spat,

* Secretaries of Societies will greatly oblige us by writing out their reports legibly—especially the technical terms—and by "underlining" words, such as specific names, which must be printed in italics. They will thus ensure accuracy and enhance the value of their proceedings.—Ed. M. M. J.

† Report supplied by Mr. R. T. Lewis.

thinking that whilst it was probable that these creatures were hermaphrodite, and capable of self-fecundation, yet it seemed also probable from analogy that the spermatozoa of other individuals would be prepotent, and that, as in plants, crossing was most likely to cause great improvement in the breed. Mr. W. Hislop read a paper "On a New Analyzing Selenite Stage," the subject being illustrated by diagrams and by the apparatus described. A paper was also read by Dr. John Matthews "On a New and Simple Mode of Micrometry." This ingenious contrivance consisted in having two adjustable points of steel fitted to the eye-piece in such a way that they could be made to move across the field of view, and measure the diameters of objects in the same way as a pair of callipers, the value of such measurements being afterwards ascertained by removing the object and substituting a stage micrometer. Several important advantages were claimed for this instrument, which was exhibited in the room, and attracted much attention. Mr. H. F. Hailes drew attention to some specimens of a new form of porcelain shade for microscope lamps, which he had made the subject of a paper in February last; the articles were now ready for delivery by Mr. Baker, of High Holborn. Mr. W. Hislop also mentioned that a new 3½-in. objective, by Mr. Smith, jun., was being exhibited in the room, and he made a few observations upon the desirability of ascertaining the temperatures at which micro-crystals were formed, and introduced to the notice of the members a new thermometer, which had been constructed for him by Mr. Hill for this purpose. Cordial votes of thanks to the readers of the papers were carried unanimously. The chairman announced the meetings and field excursions for the ensuing month, and the proceedings terminated with a conversazione, at which a number of very interesting objects were exhibited.

Brighton and Sussex Natural History Society.

Sept. 9th.—Annual meeting, at which the Committee's report for the year was presented, and the officers for the ensuing year elected. President—Mr. T. H. Hennah. Committee—Messrs. G. W. Sawyer Noakes, J. Dennant, R. Glaisyer, and the Revs. J. H. Cross and J. Image. Treasurer—Mr. T. B. Horne. Hon. Secs.—Mr. T. W. Wonfor and J. Colbatch Onions. Hon. Librarian—Mr. Gwatkin. After which the ordinary meeting was held (a microscopical one), at which Mr. T. Hennah exhibited living beetle, showing structure of mouth, and *Marchantia polymorpha* in fruit and elaters of same; Mr. Smith exhibited fructification of Hepaticæ; Mr. Glaisyer exhibited *Sphagnum squamosum*, with porous cells and spiral fibres; Mr. Gwatkin exhibited skin of toad, Fossil wood from Great Desert, lung of boa constrictor, and large intestine of ostrich; Dr. Hallifax, section of lady-bird, showing optic and ventral ganglia; ditto of bee, showing tongue and suctorial apparatus; ditto of common fly, showing proboscis and eggs of parasites of Bohemian pheasant and Mallee bird; Mr. T. Cooper exhibited sections of yew, &c., embryo oysters, and Polycistina; Mr. R. Glaisyer exhibited sections of crab-shell, prima

and mitra shells, and Australian foraminifera; Mr. Davidson showed foraminiferæ from Nice; Mr. Wonfor exhibited *Pleurosigma formosum* and *P. angulatum* with a Reade's prism, injected preparation of Dr. Thudichum's Trichinous rabbit, and a series of the South American pest *Pulex penetrans*, chigoe or jigger, kindly lent by Mr. T. Curties, of Holborn. There were also exhibited by Mr. Baker, of London, Wright's and other collecting bottles, lamp chimneys to give white cloud light, Reade's prisms, and other apparatus.*

Microscopical Society of Liverpool.

The seventh ordinary meeting was held at the Royal Institution on Tuesday, 6th July. The President, Dr. Nevins, in the chair. A paper was read by the Rev. W. H. Dallinger, on "Spontaneous Generation." The author said that the present position of science was attributable solely to its stern adhesion to truth. It admitted no inference that was not firmly based on fact, and suffered no generalization but such as accumulated fact rendered almost axiomatic; but, although the leading minds of science were in harmony with its principles, they were sometimes led to generalization upon hypothetical "facts." To a mind cultured to scientific thought, and trained to scientific induction, nothing was more incongruous than that certain biological phenomena—call them electric, or magnetic, or mesmeric, or what you will—because they are beyond the reach of immediate interpretation, should be hastily generalized into the supernatural, and branded with the name of "spiritualism." Now, the powers and perfection of the microscope have recently been greatly augmented The consequence of this is that the lower organisms and minute vital developments of nature have been subjected to the strictest scrutiny. With powers magnifying variously from 200 to 15,000 or 20,000 diameters, earnest and enthusiastic minds have challenged nature for the mystery of life, and strange facts have come to us. But these "facts" are many of them incongruous and conflicting, and the correlations of many more are entirely hidden. Nevertheless they appear to some thinkers to point in an anticipated direction, and, strangely enough, some few of the very master minds of science have committed themselves to a generalization in a name, and called the phenomena "spontaneous generation." Mr. Dallinger said he was not anxious to deny or to defend the theory; all he asked was stern fact, and not hypothesis from which to infer. As a minister of the Gospel, he had no fear of "spontaneous generation," provided it could be shown to be a correct interpretation of the facts of nature; but that it should be this he respectfully contended. The two antagonistic theories of life—the one that it was simply a correlative of the forces of nature, making life "not independent of matter, but a condition of it," and declaring "that there is no boundary line between organic and inorganic substances;" the other, that it was a force distinct from matter and independent of it, called "vital force"—were carefully explained and illustrated by quotation. The question, it would appear, could

* Report supplied by Mr. T. W. Wonfor.

only be settled by a careful examination of the lowest and minutest forms of life. Now, it was well known that if an "infusion" of animal or vegetable matter were placed in, say a glass vessel, and left for some hours, it teemed with life in its lowest forms—molecules, bacteria, vibrios, and even ciliated animalcula. Nor was an "infusion" necessary. Water taken from a shower of rain after drought was equally efficient. What, then, is the origin of these? Do they result from some physical force, uniting the fortuitous particles in the water? or are the ova of these living forms—immeasurably minute—floating in the air, deposited in the water, the element of their development and life? To answer this question in a scientific way it was evidently essential that we should be absolutely certain that the water does not contain the germs of these vital forms. To say that they are not seen when the infusion is first made, is—even if the assertion be granted—only to suggest that your powers of research are not equal to this discovery. There must be, not assumption, but certainty. This might be done by producing the water synthetically from its pure element. This the author carefully did by reducing the black oxide of copper with hydrogen, procuring about a wine-glass of water. This was divided into three parts. One part was placed in an exhausted flask, and the ingress of air prevented. Another third was placed in a U-shaped tube, and the open ends plugged with cotton wool, thus causing the air to be "wiped" in its passage to the water. The third part was freely exposed. In five days the exposed vessel teemed with bacteria and vibrios. In eight days the water in the plugged tubes was searched and was almost entirely void of life. In twelve days that in the flask was carefully examined with the $\frac{1}{12}$-inch and $\frac{1}{25}$-inch objectives of Powell and Lealand, and absolutely nothing was discovered. This was repeated with the same results. But in this instance the flask, at first exhausted of air, was next supplied with air of which the elements (oxygen and nitrogen) had been carefully produced in the laboratory. But no life resulted. The same water was then freely exposed to the air, and in four days abundance of bacteria were found. Infusions of hay were then used: some vessels, containing portions of the same infusion, being exposed to an artificial atmosphere, others to the natural. Life was found in both alike, only apparently in greater abundance in the former. Hence, then, the ova did not come from the air alone, if at all. Therefore if the germinal forms existed they must have existed in the infusion.

After a few remarks from the President, the meeting concluded with the usual conversazione.

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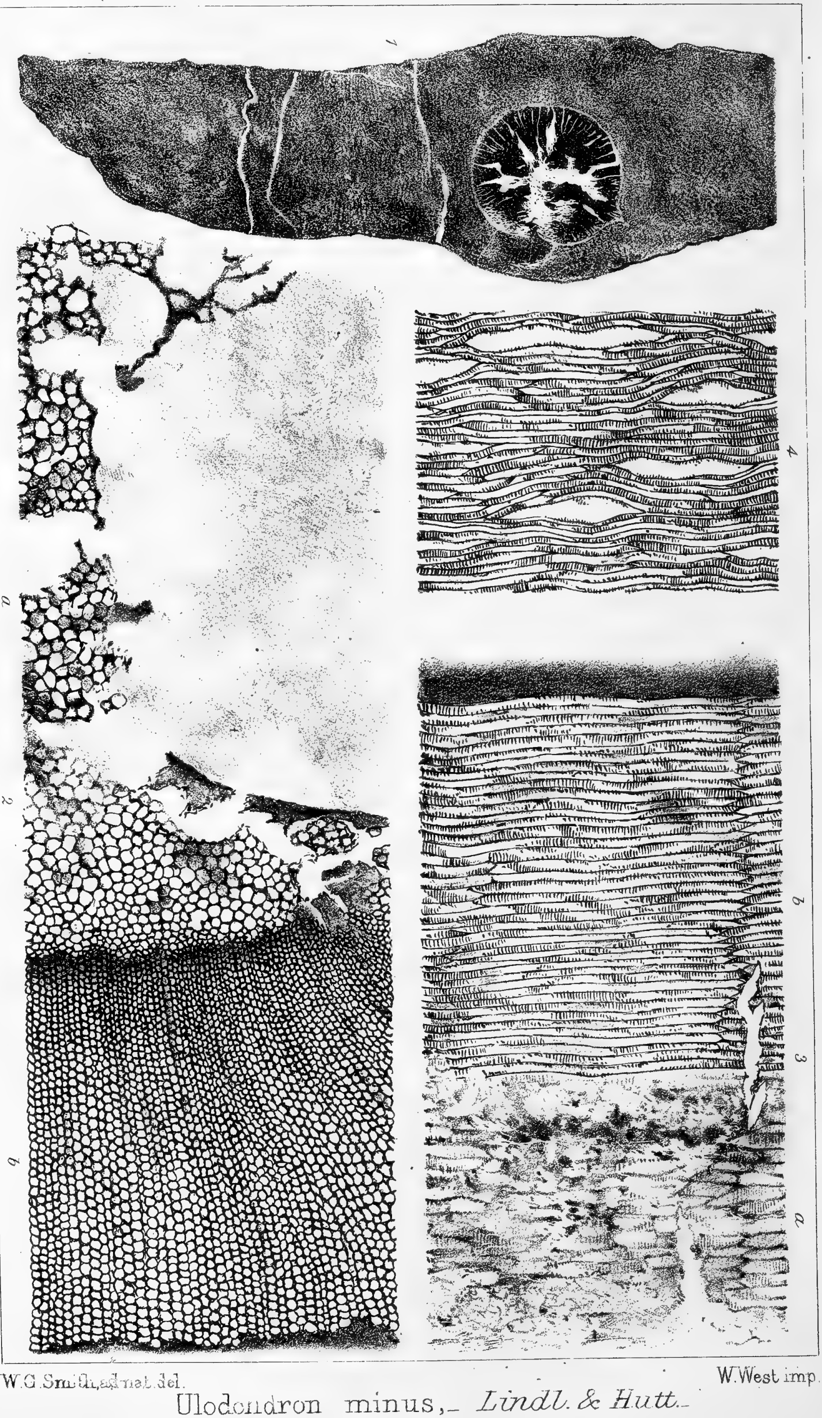

W.G. Smith, ad nat. del. W. West imp.

Ulodendron minus,— *Lindl. & Hutt.*

THE

MONTHLY MICROSCOPICAL JOURNAL.

NOVEMBER 1, 1869.

I.—*On the Structure of the Stems of the Arborescent Lycopodiaceæ of the Coal-Measures* (*Ulodendron minus*, Lindl. and Hutt). By Wm. Carruthers, F.L.S., F.G.S., Botanical Department, British Museum.

Plate XXXI.

The genus *Ulodendron* was established by Lindley in the "Fossil Flora" for a group of Lepidodendroid stems, which, besides the rhomboidal leaf scars arranged spirally on the stem as in *Lepidodendron*, had deep oval or circular cavities ranged in two vertical rows on opposite sides of the trunk. Several species have been recorded, all of them from the Coal-measures. Professor Morris, in the last edition of his Catalogue of British Fossils, gives the names of seven species; but some of these must be reduced to synonyms. Belonging to the same group are two other forms which have received generic designations, but which should be placed, I believe, in this genus. These are *Megaphyton* and *Bothrodendron:* the only character which distinguishes the latter genus from *Ulodendron* is the obliquely oval form of the vertical scars. *Megaphyton* is based upon amorphous casts of a portion of the interior of the stem of *Ulodendron.* The series of scars represent the cavities, through which the vascular bundles to the vertical appendages passed, as they existed on the inner surface of the

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EXPLANATION OF PLATE XXXI.

Fig. 1.—Transverse section of a little more than half of the flattened stem of *Ulodendron minus*, Lindl. and Hutt., showing the scalariform axis—natural size.

„ 2.—Transverse section of a portion of the axis. *a.* the large irregularly-arranged scalariform vessels of the interior. *b.* the smaller radiating scalariform vessels of the investing cylinder. The tissues have been destroyed in the light-coloured portions, and the space filled in with carbonate of lime.

„ 3.—Longitudinal section of the same, lettered as in Fig. 2.

„ 4.—Longitudinal tangential section, showing the openings between the vascular bundles.

layer of elongated cells corresponding to that in *Lepidodendron selaginoides*, marked *e* in Figs. 1 and 2 of Plate XXVII.

The specimens of *Ulodendron* are most frequently casts in sandstone of the outer surface of the stem, or amorphous casts of the interior formed in the cavity left in the rock after the more or less complete decay of the original organism. Impressions of the scars are occasionally seen on the surface of the laminæ in bituminous shales.

The specimen figured on Plate XXXI. is in the collection of the late Robert Brown, now in the Botanical Department of the British Museum. It has the label, "Coal Measures—Hemsford or Bradford—Rev. R. B. Cook, F.G.S., Doncaster." It is a fragment measuring $7\frac{1}{2}$ inches in length, 5 inches in breadth, and $1\frac{1}{4}$ inch in thickness. The surface is covered with the carbonized remains of the scale-like leaves arranged in a quincuncial manner. It is very much flattened, and exhibits three round conical pits characteristic of the species on each of its two edges. About two-thirds of the transverse section is shown at Fig. 1 of the natural size. The greater portion of the interior is composed of amorphous shale, but the tissues of the centre are more or less perfectly preserved. This forms a well-defined cylinder $\frac{8}{10}$ths of an inch thick in diameter. It corresponds to the axis and surrounding cylinder of vascular tissue in *Lepidodendron selaginoides*, Sternb. (Plate XXVII., Figs. 1 and 2, *a* and *b*), and consists of similar tissues.

The transverse section (Fig. 1) shows that the inner portion is somewhat decayed; the cavities have been filled in with white crystallized corbonate of lime. Sufficient of the original tissue, however, remains to show clearly what it was. In the enlarged portion (Fig. 2 *a*) it is seen to be composed of vessels of different sizes, and of a circular or polyhedral form in transverse section. They do not appear to be arranged as I have described them in *Lepidodendron selaginoides*. The larger vessels are found in the interior, and amongst them a number of smaller vessels are irregularly intermixed. Towards the circumference the vessels are uniformly smaller, but they do not alter their form, being as nearly circular as those of the interior. In longitudinal section (Fig. 3 *a*) they are seen to be scalariform vessels. Their apparent shortness in the drawing arises from the direction of the section exhibiting a somewhat oblique cut through the vessel, and not from their actual terminations being seen.

The axis is surrounded by a cylinder of radiating scalariform tissue (Figs. 2 and 3 *b*). At its inner margin the diameter of the vessels composing it are small—their size increases outwards. I have not been able to detect any structure in this cylinder besides the scalariform vessels. The radiating lines are frequently separated by portions of calcite containing no organic structure. None of

these spaces occur in the portion enlarged at Fig. 2 *b*, which was accurately drawn with the aid of the camera lucida. In the longitudinal section (Fig. 4), made at right angles to the radius, several of these openings are shown. There is an apparent approach at regularity in their arrangement, which induces me to suppose that they may be the openings through which the vascular bundles passed to the leaves. They may, however, be only cracks produced in the desiccation of the tissues.

Beyond this cylinder no structure is preserved, until we reach the surface of the stem with the impressions of the leaves and the series of larger scars. The parts preserved agree so nearly in regard to the nature and arrangement of the tissues with what I have described in *Lepidodendron selaginoides* (Sternb.), that there cannot be any doubt as to the close affinities of these two stems. The structureless space represents the portion occupied with the delicate parenchyma, the more thickened and larger parenchyma beyond, and the elongated cells of the outer portion, together with the true bark. The proportion between the scalariform cylinder and axis and the external layers of parenchyma is the same in both stems. In the *Lepidodendron selaginoides*, figured on Plate XXVII. in the October number of this Journal, the cylinder measures $\frac{1}{5}$th of an inch, and the whole stem is an inch in diameter, while in the *Ulodendron minus*, figured on Plate XXXI., the scalariform structures are $\frac{4}{5}$ths of an inch in diameter, and the stem in its original cylindrical form measured 4 inches. The proportion of the axis in both is $\frac{1}{5}$th of the whole stem.

II.—*The Histology of the Eye.* By John Whitaker Hulke, F.R.S., F.R.C.S., Assistant-Surgeon to the Middlesex Hospital, and Surgeon to the Royal London Ophthalmic Hospital.

The eye is a *microcosm*—a very compendium of all the tissues. True *cell-tissues*, *connective tissue* in several forms, *muscular*, *vascular*, and *nervous tissue*, are all represented here; and there is not another part of the whole human body which offers such facilities for direct clinical observation, and for the anatomical investigation of the minute tissue-changes produced by disease.

Cornea.—The cornea is composed of three distinct structures: an *outer* or conjunctival layer, which, at the circumference, passes into the loose conjunctiva covering the sclerotic; a *middle* layer, the proper or lamellated cornea, which is uninterruptedly continued into the sclerotic; and a very delicate *inner* layer, having complex peripheral relations with the sclerotic, ciliary muscle, and iris.

The *conjunctival layer* consists of an *epithelium*, underlaid by a *homogeneous stratum*, known as "Bowman's membrane," or the "anterior elastic lamina."

The *epithelium* is composed of four or five superposed rows of cells, the aggregate thickness of which averages $\frac{1}{430}$th of an inch. The deepest cells are subcolumnar. Their inner ends are straight, and they rest directly on Bowman's membrane. Their outer ends are convex; and they form generally a crenated line, which interlocks with the cells immediately external to it. These intermediate cells have a jagged inner border, and a convex outer contour. The outermost cells are large flat scales.

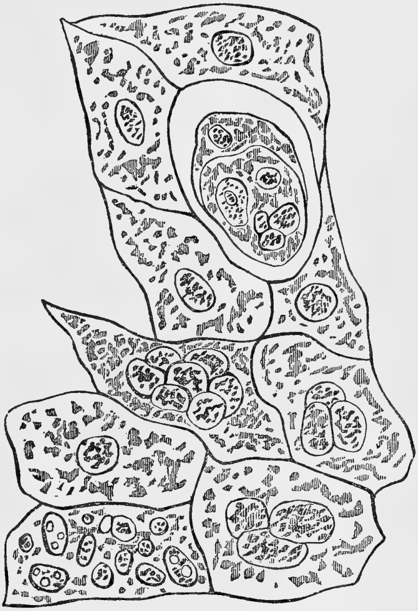
The structural and chemical distinctions which so sharply separate the horny from the mucous stratum of the epidermis are wholly absent from this epithelium, all the cells of which, the outermost as also the deepest, are nucleated, and are capable of manifesting every endowment of cell-life proper to them; and this alone would be enough to throw great doubt on the commonly assumed parallelism between the manner of the renewal of the corneal epithelium and that of the epidermis. The common idea, that the deepest epithelial cells constitute a sort of matrix, from which there is a constant progression of nascent cells towards the outer surface to replace the loss by exfoliation, has been lately challenged by Dr. Cleland, who, from a study of the corneal epithelium in the ox, concludes that not merely the external waste, but also the internal decay of the deepest cells, is made good by new cells evolved out of those of the middle tier. My own observations lead me to believe that an outward progression of cells from the innermost tier really does take place, but that all the superficial cells are not directly referable to this source, since proofs of cell-multiplication are met with at every depth in the epithelium.

But the formative energy may take another direction, and produce from the epithelium a progeny unlike the parent. Wounds and ulcers, again, afford us abundant illustrations of this perversion. Around these we find the epithelial cells enlarging; their nuclei, or masses of germinal matter, dividing and subdividing until the parent cell is filled with a brood which we cannot optically distinguish from the corpuscles of granulation, or lymph, or pus, and which, when set free by the deliquescence of the parent capsule, we recognize as the formed elementary constituents of granulation-tissue, of lymph, or of pus. (Fig. 1.)

Bowman's Membrane: Anterior Elastic Lamina.—Beneath the anterior epithelium, between it and the lamellated cornea, is the structureless stratum first particularly described by Mr. Bowman, and named by him the *anterior elastic lamina.* In several early human fœtal eyes I found that this stratum was

not yet differentiated; but at full term it is very distinct. In the adult cornea, in which its average thickness is about $\frac{1}{1500}$th of an inch, it is always remarkably conspicuous by its transparent structurelessness, which marks it off from the epithelium in front and the lamellated corneal tissue behind it. The front of the lamina bearing the epithelium is perfectly even; while the posterior surface is slightly irregular, owing to the production of fibres which pass slantingly from it into the lamellated tissue, and tie the lamina to this so closely that it is inseparable from it by dissection, except in very minute pieces. These *tie-fibres*, originally described by Mr. Bowman, are, I believe with him, of the same nature as the lamina—a modified connective substance; and they are perfectly distinct from the nerve-fibres, the tracks of which a recent author supposes them to be.

Fig. 1.



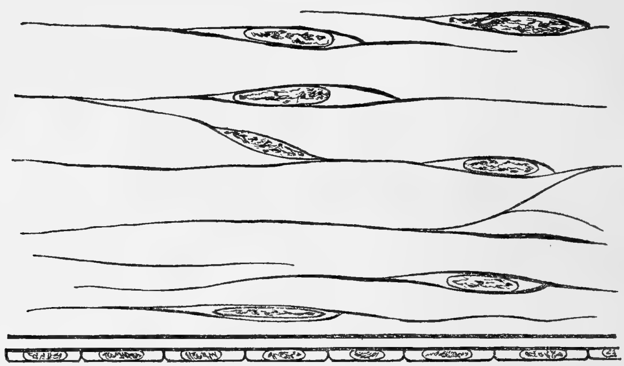
Suppuration of Anterior Corneal Epithelium.

The peripheral relations of the anterior elastic lamina are very simple. It becomes suddenly thinned at a short distance in front of the foremost conjunctival vessels, and thence runs backwards over the loose submucous tissue as the basement-membrane of the conjunctiva bulbi.

The next structure is the *lamellated cornea*, one of the group of connective substances. It is mainly composed of two elementary tissues—one cellular, the other a modification of common connective or white fibrous tissue. Their microscopic characters and the proportions in which they occur are not the same at all ages. At its first appearance, the cornea, embryology teaches, is purely a cell-tissue; and, in the earliest human fœtal cornea which I have examined (at the fourth month), the cell or corpuscular tissue has greatly preponderated. At full term, the disproportion is less: the cells have still simple shapes; but they are separated by a larger quantity of interstitial tissue, which is very distinctly fibrillated. In the adult's cornea, the fibrous tissue dominates; and the corpuscles are large-branched cells, cohering in nets of variable sizes,

but never co-extensive with more than a very small fraction of the entire corneal area. (Fig. 2.)

Fig. 2.



Vertical Section of the Cornea.

The cell-nets extend in planes which intersect one another at every possible angle, preserving always more or less parallelism to the corneal surfaces.

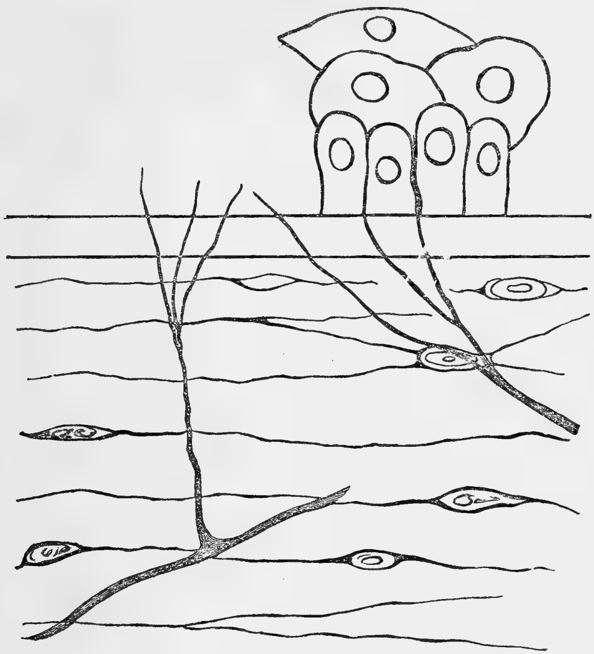
Corpuscles lying in the same plane intercommunicate very freely through their branches, and less freely with those in the neighbouring more superficial and deeper planes; and in this way they collectively form a system of plasmatic canals, which pervades the entire cornea.

The *interstitial fibrous tissue* consists of broad flat lamelliform bundles, interwoven with the cell-nets, necessarily also in planes more or less parallel to the corneal surfaces—an arrangement of the tissues which gives the quasi-laminated appearance observable in vertical sections of the cornea. In the fœtus, the fibrillation of the bundles is very distinct; and in the adult it is also evident.

Blood-vessels are entirely absent from the healthy adult cornea, the nutrition of which is wholly carried on by the corpuscular system, which draws its plasma from the vessels of the sclerotic and conjunctiva. Its *nerves*, however, are numerous. The distribution of the coarser bundles is easily demonstrable. They enter the circumference of the cornea, and converge towards its centre, repeatedly dividing and uniting in a plexus, most of the bundles of which tend towards the anterior surface. Near here they recombine in a plexus of very fine bundles, from which minute branches are detached towards the anterior elastic lamina, which they perforate, and reach the anterior epithelium. (Fig. 3.) The exact relation of the nerve-fibres to the epithelium is so delicate a subject of inquiry, that it cannot surprise us that different opinions have

been arrived at respecting its nature. The passage of the perforating nerve-fibres quite through the epithelium, and their free termination at the outer surface of this, described by one observer

Fig. 3.



Corneal Nerves perforating the Anterior Elastic Lamina.

(Cohnheim), requires, I think, confirmation. I have not myself succeeded in tracing these fibres beyond the middle tier of epithelial cells; nor have I yet been able to demonstrate their ultimate distribution.

The only remaining corneal tissue is the *delicate membrane* which lines the posterior surface of the lamellated tissue, called after *Démours and Décémet,* and sometimes also named the *posterior elastic lamina.* Its thickness is only about one-third of that of the anterior elastic lamina. It is perfectly homogeneous, without the slightest trace of structure. It is separable from the lamellated tissue by careful dissection in pieces of large size.

A single layer of delicate pavement-epithelium lines the inner surface of the lamina. Its cells poliferate in some forms of keratitis, and produce minute opaque dots upon the back of the cornea, recognizable when illuminated by an oblique pencil of light.

Vitreous Humour.—This, in a perfectly healthy state, is a clear, colourless mass of gelatinous consistence, enclosed in a hyaloid membranous capsule.

In the *adult*, the traces of structure perceptible in it are scanty and indistinct, conveying a very imperfect idea of its anatomical composition; but in the *fœtus* its formed elementary parts are recognizable without difficulty, and their combinations are easily made out; so that we naturally turn to embryology for aid; and this, as in so many other instances, explains points in the anatomy of the adult organ which would otherwise remain unintelligible.

Genetically, the corpus vitreum is an extension of the deeper stratum of the cutis, intruded into the secondary eye-vesicle between the lens and the nervous lamina which becomes the retina.

In order to make this quite clear, I must ask your attention to some matters in the development of the eye.

The first trace of the eye in the chick, which makes its appearance very early, is a hollow protrusion from the *front and lateral part* of the *foremost cerebral vesicle.* Gradually, as this cerebral vesicle enlarges forwards, and divides into the two segments which Von Baer called the *Vordernhirn* and the *Zwischenhirn*, the primary eye-vesicle shifts its place backwards and downwards until at length it lies beneath the *Zwischenhirn;* there it becomes *pedunculated.* The *stalk*—the future optic nerve—at first is hollow, and through it the cavity of the eye-vesicle communicates freely with the cerebral ventricle.

The upper side of the eye-vesicle, where the stalk is placed, is towards the *Zwischenhirn;* whilst its opposite side is towards the external tegument, which here consists of the epidermal stratum only, as Remak thought, or which includes, as Kölliker believes, a part of the cutis. At this spot the epidermis thickens; and an *inbud* of it, pressing on the summit of the primary eye-vesicle, pushes this inwards, so changing the *globular* shape of the vesicle into a *cup* consisting of an inner and an outer plate, separated by an interspace, the remnant of the original cavity of the first vesicle, which continues for some time longer to communicate with the brain-ventricle through the still hollow eye-stalk.

The cup thus formed, distinguished as the *secondary eye-vesicle*, is incomplete below; and through this gap—*the fœtal cleft*—the deeper stratum of the cutis intrudes between the epidermal inbud, which is the matrix of the lens, and the anterior plate of the secondary eye-vesicle, which is the foundation of the retina.

It will be perceived that this intruded portion of cutis fills the space in the secondary eye-vesicle which corresponds to that in the completed eye occupied by the vitreous humour. So long as the fœtal cleft remains open, the intruded portion of cutis (which we may now call the vitreous humour) is directly continuous through

it with the exterior cutis, and nutrient blood-vessels enter the vitreous humour through this channel. At a later stage, the fœtal cleft closes, which perfectly isolates the internal corpus vitreum from the external cutis. Von Ammon says that the closure of the fœtal cleft begins at its middle, and proceeds hence in both directions, forwards and backwards.

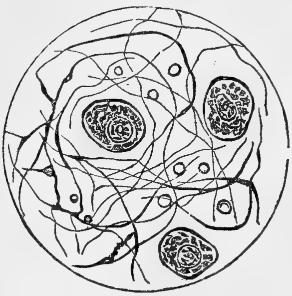
Simultaneously with the transformation of the primary eye-vesicle into the secondary, the hollow eye-stalk became solid by the approximation of the upper and lower plates, and acquired the form of a flat ribbon. Next, by the inbending of its edges, the ribbon became a gutter, along which the blood-vessels gained the inside of the eye; and, lastly, the gutter, closing in the eye-stalk, takes the cylindrical form of the perfect optic nerve, and includes the blood-vessels within it.

Our knowledge of the distribution of these vessels is still very imperfect. Von Ammon, whose articles in the 'Archiv für Ophthalmolgie' are a fund of information on the embryology of the eye, says that the *arteria centralis,* immediately on entering the globe, gives off *fine twigs to the sclerotic and choroid;* next it detaches several *lateral branches to the retina,* upon the inner surface of which they spread out and form the *membrana vasculosa fœtalis retinæ;* then it sends off a second set of lateral branches, from five to seven in number, which ramify on the outer surface of the hyaloid capsule, forming here the *discus arteriosus hyaloideus;* and, finally, the diminished trunk, traversing a canal in the vitreous humour, is distributed to the vascular capsule of the lens. Thus Von Ammon describes *two vascular nets*—one *retinal,* the other belonging to the *vitreous humour;* but this has not been confirmed by later observers. The late H. Müller distinctly says that there are not any other vessels on the outer surface of the corpus vitreum than the retinal ones; and he also mentions that the retina continues long without blood-vessels—a fact which I have myself verified in the human fœtus, the moment of their appearance being apparently determined by that of the obliteration of the arteria hyaloidea capsulæ lentis. In the human fœtus of the fifth month, in which all the retinal layers except the bacillary were distinctly recognizable, I found the retina still quite devoid of blood-vessels; the axial vessels going to the lens-capsule were still pervious; and I failed to detect the vascular net on the hyaloid capsule described by Von Ammon.

Absolutely fresh human embryos are so rarely obtainable that the structure of the human vitreous humour in the earliest stages of development is unknown. Before and after the fifth month it consists of a web of delicate fibres, the meshes of which contain a viscid colourless substance. Throughout this tissue, in chromic acid preparations, numerous minute bright globules occur, which,

mingled with the fibres, give, under a moderate enlargement (a quarter of an inch) some resemblance to a stellar tissue. This resemblance is, however, only superficial, and disappears under a higher magnifying power which makes it evident that the bright globules have not any definite relations to the fibres, since some of them lie free in the meshes of the web, and others cohere singly or in groups to the sides of the fibres or at their intersections. Examined with one-twelfth or one-twenty-fifth objective, these bright globules do not exhibit any trace of structure; and I am disposed to conjecture that they are artificial products, resulting from the action of the chromic acid on the interstitial albuminous substance. (Fig. 4.)

Fig. 4.



Fœtal Vitreous Humour.

But, besides the formed elements just described, there occur in the fœtal corpus vitreum *other elementary parts of the highest physiological importance*—large nucleated cells, which are most abundant upon and near the hyaloid capsule and around the central canal, but which are also found throughout the whole organ. Most of them have a simple round or roundly oval shape; some are fusiform and branched. All are distinctly nucleated. Their diameter ranges between $\frac{1}{4300}$th and $\frac{1}{860}$th of an inch.

In the human adult's vitreous body, the fœtal fibrillary net steps into the background; but it does not wholly disappear, for portions of it persist even to old age; and it is replaced by delicate membranes of such extreme tenuity, and differing so little in their refraction from that of the fluid substance of the organ, that they would elude detection, but for the presence of folds and the adhesion of minute impurities to them. The arrangement of these membranes is not yet certainly known; and, in truth, their very existence is doubted by some anatomists.

Beyond all doubt, the most important constituents in the adult's corpus vitreum are the large nucleated cells which I mentioned as occurring in the fœtus. These embryonal cells persist throughout life, and they are the starting-point of many of the morbid changes to which this organ is subject.

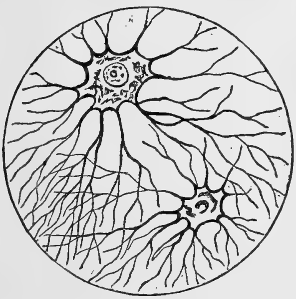
They are endowed with an extraordinary formative energy, normally latent, but promptly responsive to an appropriate stimulus, the nature of which determines the dynamical direction this energy takes. Anatomically, this excessive formative energy principally manifests itself in two ways—one marked by a remarkable extension and fission of the cell-wall and contained protoplasm; the other characterized by inordinate proliferation of the nucleus. The

first produces, in its most complete form, very finely fibrillated tissue. (Fig. 5.)

Where the fission of the cell-wall is carried to a less degree, it produces open fibre cell-nets of coarser texture, which are often combined with corrugated hyaloid membranes.

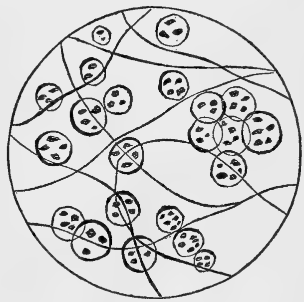
Proliferation of the nucleus in a minor degree is common in association with chronic irritative affections of the vascular coats—*e. g.* chronic glaucoma and the late stages of posterior staphyloma, in which we find the cells larger than normal, but still retaining

Fig. 5.



Fibrillation of Cells of Vitreous Humour.

Fig. 6.



Proliferation of Cells of Vitreous Humour.

their simple forms, and containing two, three, or several nascent cells, instead of a single nucleus. But it is in suppuration that proliferation is carried to its highest development. Advanced cases, where the entire corpus vitreum is changed into a tough yellowish substance, are not suitable for the demonstration of this; but, before its metamorphosis is complete, at an earlier stage, in which the opacity due to the presence of pus diminishes from the exterior towards the still transparent centre of the organ, all the intermediate phases between the simple mononucleated embryonal cell and perfect pus are easily traceable. (Fig. 6.)

The *Tunica Uvea*, so named from its resemblance to a grape or large berry, *uva*, consists of two segments—the iris and the choroid—which differ in their principal anatomical constituents and in the offices which they subserve in the physiology of vision, and agree mainly in both of them containing numerous blood-vessels and much pigment.

The *Choroid* corresponds to the coat of lamp-black with which we line the interior of the camera obscura, and serves the same purpose, absorbing the incident rays, and so lessening dispersion in proportion to the intensity of its pigmentation. But, the eye being a living camera, the choroid has additional functions of another kind. It directly ministers to the nutrition of the bacillary stratum of the retina in man, as also to that of all the retinal strata in those animals whose retinæ are devoid of blood-vessels.

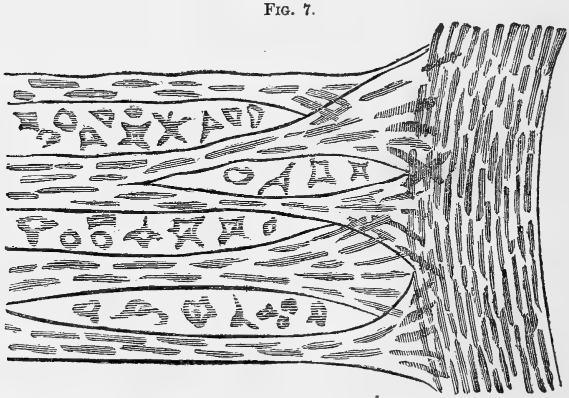
The *Iris* corresponds to the diaphragm in the cornea. Stretched across the anterior chamber, it stops out the most peripheral rays, which, in its absence, would pass through the edge of the lens, and in this way it lessens spherical aberration; then, by varying the size of the pupil, it regulates the quantity of light admitted to the retina; and, finally, it is an accessory of the apparatus of accommodation, although not in man an actual factor.

The iris is essentially a *muscular organ.* The contraction and dilatation of the pupil are due to muscular irritability, and not to vascular erectility. Their continuance after the heart has ceased to beat, and even after the head has been severed from the body, are facts which place this beyond discussion.

In mammalia, the muscular tissue is of the unstriped kind; while in birds and reptiles it is striped. One of the most useful chemical agents for demonstrating it is the chloride of palladium. The iris should be placed in a solution of this, containing from one-fourth to one-eighth per cent., until it acquires a deep straw tint. The palladium chloride hardens the tissue, without making it so granular and opaque as chromic acid does; and it beautifully preserves the nuclei. With this reagent, its demonstration is easy and certain in the eyes of white rabbits, where it is unobscured by pigment which conceals it in human eyes.

The cells, which are not easily individually isolated, are long spindles containing a rod-like nucleus. They resemble closely the cells of the larger organic muscles. The cells cohere in small flat bands, and these again combine in larger bundles. In man, I believe also in

Fig. 7.



Iris of White Rabbit, prepared with Chloride of Palladium, to show the disposition of the Muscular Tissue.

mammalia generally, in birds, and in reptiles, the muscular bundles are disposed in two sets, which have a radial and a circular direction, and constitute a sphincter and a dilator muscle of the pupil. (Fig. 7.)

In the white rabbit, the muscular bundles of the sphincter pupillæ are disposed with great regularity in lines concentric with the pupil, at the edge of which they form a very distinct band upon the anterior surface. On the back of the iris, the outer border of the muscular ring is less distinct; and here, intersecting the radial bundles of the dilator, a thin layer of circular fibres is traceable for some distance towards the great circumference of the iris.

The dilator pupillæ consists, in this animal, of slender bundles running along the posterior surface of the iris from near the great circumference towards the pupil, separating and combining again in a plexus with long narrow meshes. On nearing the sphincter pupillæ, they spread slightly, and, intersecting with one another and with the bundles of the sphincter, are lost.

The peripheral relations of the radial muscular bundles are less easily made out. The difficulty is occasioned by the greater thickness of the iris, and by the parallel direction of the very muscular arteries. I am inclined to think that the bundles attach themselves to the elastic fibres, which the ligamentum pectinatum iridis prolongs inwards to the iris. This very remarkable net of elastic tissue, which fixes the great circumference of the iris to the margin of the anterior chamber, is derived from the posterior elastic lamina of the cornea, which in my last lecture I mentioned as having peripheral relations with the ciliary muscle, iris, and sclerotic. These I shall now explain. The lamina at the circumference of the cornea resolves itself into fibrous tissue. This dehiscence begins first on its anterior surface, and goes on until the whole membrane is converted into fibres, which take three principal directions. One set passes backwards and outwards to the sclerotic, behind the circulus venosus in Schlemm's canal; another set goes directly backwards to the ciliary muscle; and a third set springs across the margin of the anterior chamber to the great circumference of the iris, on the anterior surface of which they form a network remarkable for its hard stiff outlines, from which fibres are produced upon the front and in the substance of the iris for a considerable distance towards the pupil.

The *blood-vessels* of the iris are very numerous. Its arteries come from the arterial circle formed by the inosculation of the two long posterior ciliary arteries, and known as the *circulus arteriosus iridis.* The mode of formation of this arterial circle is very variable; but the ordinary plan is, that each of the two long posterior ciliary arteries divides upon the outer surface of the ciliary muscle, near its front, into a couple of primary branches, which separate and encircle the iris, and meet the corresponding branches of the other long ciliary artery. The arterial circle thus made sends branches backwards to the ciliary muscle; others inwards to the ciliary processes; and a third set run forwards to the iris through

the ligamentum pectinatum. These latter have, as Leber notices, very thick muscular walls. They run from the great circumference of the iris towards the pupil with a straight or wavy course, detaching branches to the capillary net, which is very abundant, especially at the anterior surface of the iris. On reaching the lesser circle of the iris (the little circlet of minute irregularities on the front of the iris near the pupil, which marks the attachment of the fœtal pupillary membrane), the now greatly diminished arteries join here in a second arterial ring, the circulus arteriosus minor iridis. From the inner border of this, capillaries extend inward, encroaching slightly upon the sphincter, but not quite reaching the edge of the pupil.

The veins of the iris lie nearer its posterior than its anterior surface. They pass backwards, and, joining the veinlets of the ciliary processes, convey the venous blood from the iris to the vasa vorticosa.

The iris receives its *nerves* from the ciliary plexus—that exquisite net on the outer surface of the ciliary muscle. I can strongly recommend osmic acid for their microscopical demonstration. If the iris be placed in a solution of this acid holding about one-fourth to one-half a grain per cent. for about twenty-four hours, we get the nerves blackened, and the muscular tissue only slightly stained. Stronger solutions are not so useful as the weak ones, because they blacken more, and less discriminatingly; and, if the preparations are left a little too long in them, everything is black alike, and indistinguishable. (Fig. 8.)

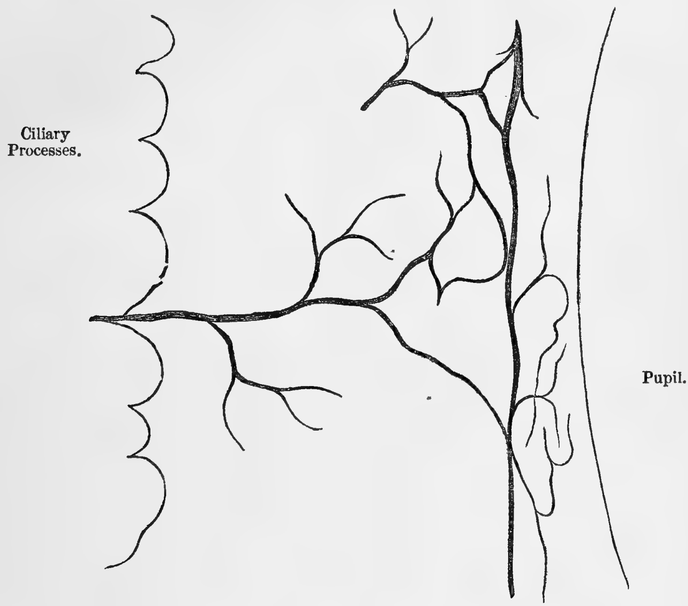
The nerves of the iris, most easily studied in white rabbits and guinea-pigs, are numerous. The larger bundles, containing several fibres, converge from the great circumference of the iris towards the lesser circle, forming, in their hitherward course, an open plexus, the larger meshes of which are occupied by a finer net. At the lesser circle, the nerves combine in a circular plexus, from which single fibres are traceable inwards in the sphincter nearly to the edge of the pupil. The coarser bundles have a very abundantly nucleated neurilemma. The nerve-tubules vary greatly in size, ranging between $\frac{1}{3375}''$ and $\frac{1}{7000}''$. All such tubules have a medulla; they are dark-edged fibres; while the smallest pale fibres which I have traced were not more than $\frac{1}{14000}''$ in diameter.

The interstices between the muscular bundles and the meshes of the vascular and nervous nets are filled with a homogeneous connective substance, in which simple, jagged, and very large, irregular, and much branched connective-tissue corpuscles, plentifully occur. Many of these contain a granular pigment, which, by its quantity and distribution, produces the different colours of the iris.

The back of the iris is overlaid with a coat of pavement-epithelium, loaded with granular pigment, which is sometimes called the

uvea or uveal surface. The cells are less regular in size and shape than those of the corresponding epithelium of the choroid.

Fig. 8.



Nerves of Iris, prepared with Osmic Acid.

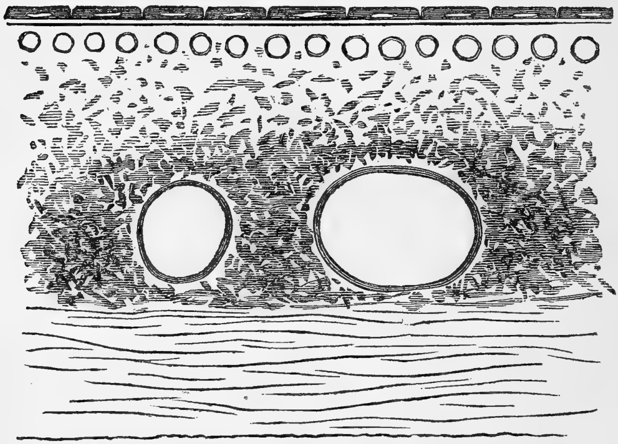
The front of the iris also has an epithelium. It is much more delicate than that on the back, and more difficult to demonstrate. Weak solutions of nitrate of silver are useful for this purpose.

In the *Choroid* we recognize two subdivisions—a larger posterior portion, reaching from the optic nerve forwards as far as the jagged line which marks the termination of the nervous retina, ora serrata; and a smaller anterior portion, lying between this and the iris, which we call the ciliary body. So much of this latter as belongs properly to the apparatus of accommodation, it is not my purpose to describe in this lecture. My present remarks will relate more particularly to the posterior segment. Its principal characteristics are, its pigmentation and its great vascularity. This latter much exceeds that of the iris; and, further, there is a peculiarity in the arrangement of the blood-vessels—the capillaries lie apart from the large vessels.

Enumerating the different tissues in the order in which they occur in passing from the inner to the outer surface of this coat, we first meet with a pavement-epithelium, borne upon a structureless

membrane, the elastic lamina of the choroid (Fig. 9); then the capillary net, called the chorio-capillaris, and by the older anato-

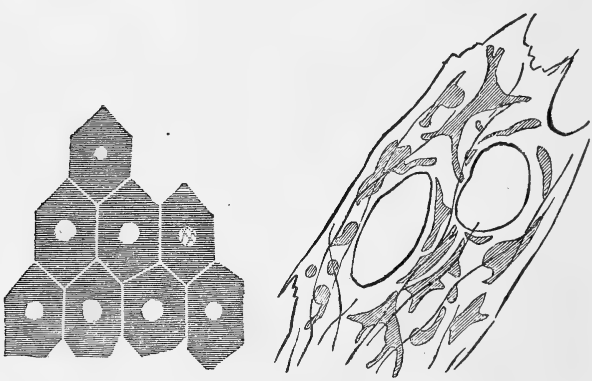
Fig. 9.



Vertical Section of Choroid.

mists the tunica Ruyschiana; next, the choroidal stroma, in which the large vessels are imbedded; and, finally, a looser connective tissue, which unites the choroid and sclerotic, named sometimes the lamina fusca.

Fig. 10.



Choroidal Epithelium. Choroidal Stroma.

The choroidal epithelium is formed of a single layer of flat polygonal, mostly hexagonal cells, containing a nucleus and some brown granular pigment. (Fig. 10.) In Albinos, in the white choroid of

cetaceans, and upon the glistening silvery portion of the choroid, called the tapetum lucidum in ruminants, solipedes, and carnivores, the epithelium is also present, but it is devoid of pigment. In birds, reptiles, fish, and amphibia, brushes of pigmented tissue pass inwards from the epithelial cells between the retinal bacilli. In man, the diameter of the cells ranges between $\frac{1}{1400}$th and $\frac{1}{2150}$th of an inch; their average is about $\frac{1}{1450}$th.

The epithelium rests on a very distinct structureless membrane—the *elastic lamina.* This is often the seat of circumscribed thickenings, which begin as little elevations of the inner surface, and grow into knobs, and globes, and glandiform masses, large enough to be seen, in a strong light, with the unaided eye. The affection is one of those degenerations common in old age, but which also occurs in young persons as a sequel of long-continued local inflammation.

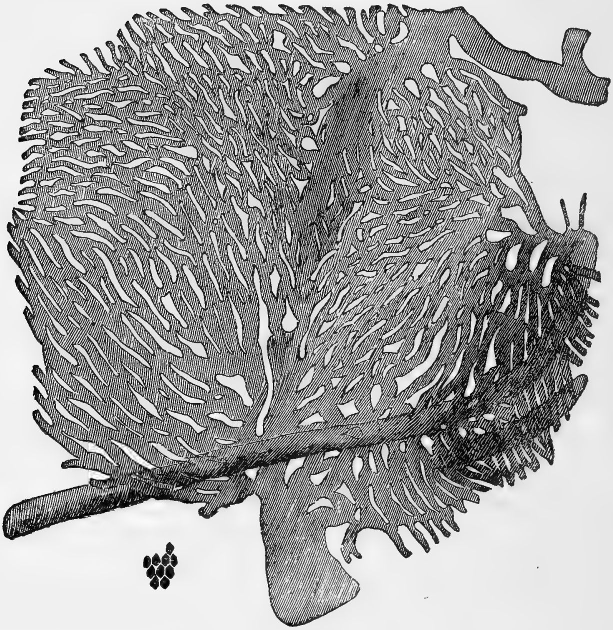
The choroid is supplied with arterial blood by the short posterior and the anterior ciliary *arteries.* The former, about twenty in number, pierce the posterior segment of the sclerotic, some near the posterior pole, others farther forwards. The hindermost are distributed to the sclera and choroid around the optic nerve: and, here inosculating with the capillaries of the nerve, they establish a collateral channel, through which a little blood can enter the retina when the trunk of the arteria centralis is plugged by an embolus. The remaining short posterior ciliary arteries run forwards with a straight course, sending off short branches through the stroma to the capillary net, where they break up quickly in an arborescent manner. The foremost of these arteries inosculate in front of the equator with the anterior ciliary arteries (branches of the muscular), which supply this region of the choroid. The capillaries form a net immediately at the outer surface of the elastic lamina, the meshes of which are smaller and less regular in the posterior segment of the choriod than in the anterior, where they are wider and longer. The vessels are large; and in all situations the interstices of the net are relatively narrow, less broad than the diameter of one of the overlying epithelial cells. We can recognize the collective effect of the capillary net, but not the individual vessels composing it in the living eye. (Fig. 11; p. 242.)

The blood of all the choroidal capillaries is collected by the well-known venus whorls, vasa vorticosa, which empty their contents by four short wide trunks which pierce the sclerotic very obliquely a little behind the equator. The valvular form of these sclerotic canals has been noticed by Leber, who adds the remark that it would tend to hinder the exit of the venous blood whenever there is an increased pressure on the inner surface of the eye-ball.

The *stroma* in which all the larger arteries and veins are bedded is a modified connective substance. It contains, like that of the

iris, branched pigmented corpuscles, which hang together in nets and membranes, and send off long and very fine elastic fibres. The

Fig. 11.



Chorio-capillaries.

thin layer of looser tissue external to the large vessels—the lamina fusca—has an essentially similar structure.

Besides the branched and irregular pigment-cells, the stroma always contains many pale, inconspicuous, roundly oval, and round cells and nuclei, of about the size of lymph-corpuscles, which increase considerably in number in inflammation, and which are, I think, the tissue out of which the formed elementary products of inflammation are evolved.

The *nerves* which we meet with in the choroid come from the ciliary ganglion; they lie quite on the outer surface, often in grooves in the inner surface of the sclerotic; and they all pass forwards to the plexus on the outer surface of the ciliary muscle. Whether any are distributed to the choroidal tissues has not yet been made out with certainty; but there is this in favour of it, that in the posterior segment very fine bundles of fibres, as well as single tubules, occur.

In both the choroid and in the ciliary plexus, pale as well as

dark edged nerve-fibres occur. In both situations, ganglion-cells are present. These latter were, I think, discovered first by H. Müller and by Schweigger. Their demonstration is not always easy, or even a certain matter.

In front of the ora serrata, the inner surface of the choroid exhibits a circle of vascular plaits. First rising gently above the surface, and then projecting freely, these compose the pars striata of Zinn and the familiar ciliary processes. They are covered with a pigmented pavement-epithelium, the cells of which are less uniform than those of the posterior segment of the choroid. Each ciliary process is a vascular plait, composed of large capillaries, which receive their arterial blood by two or three branches, which come off directly by a short trunk from the circulus arteriosus major iridis, or which arise nearly as often together with one of the arteries proceeding to the iris. The little arteries enter the outer surface (or rather edge) of the processes; and small veinlets run along the inner or free border; and they form a long meshed venous capillary plexus, which conveys the venous blood backwards to the vasa vorticosa. This venous capillary plexus not only transmits all the blood from the ciliary processes, but it also receives veins from the iris, as also some from the ciliary muscle.

In all vertebrates (except the lowest fishes, *e. g.* myxine and lancelet) a section vertical to the surfaces of the retina shows the following superposed layers.

First, there is a layer of columnar bodies, the rods and cones abutting against the choroid—the bacillary layer, known also as Jacob's membrane. To this succeeds the layer of corpuscles called the outer granules. Next follows a fibrillated stratum—the intergranule layer; then another layer of corpuscles, the inner granules; next to this the layer, called by some the granular layer, by others the grey vesicular or grey nervous layer; then a stratum of ganglion-cells; and, finally, a stratum of optic nerve-fibres, bounded internally by a thin membrane, the "membrana limitans interna retinæ."

In all these layers, nervous and connective tissues are intimately commingled; and it is just this interpenetration of the two tissues which constitutes our principal difficulty whenever we attempt to decide the nature of a particular retinal element.

Before proceeding to a detailed account of its tissues, a few words on the best methods of studying the retina may be useful to some readers. First, it is absolutely essential that the eyes be perfectly fresh—the lapse of half-an-hour after the circulation has ceased, or even of a few minutes if the eye have been opened, makes differences in the appearance of the bacillary elements. Next, the outer surface of the fresh retina should be carefully scrutinized, in order to learn if both rods and cones are present. The latter will be known by their greater stoutness, and by their outer ends lying

in a deeper level than those of the rods; while in birds, in some reptiles, and in the batrachians, they are immediately betrayed by their bright-coloured beads.

But there are many things which cannot be made out in the fresh retina, or which can only be recognized by a practised observer already familiar with their characters when they have been artificially hardened and stained. The fresh retina is also too soft to allow us to cut vertical sections sufficiently thin without greatly disturbing the tissues. The most useful agents are chromic and osmic acids. Of the former acid, solutions of about a half per cent. are most useful; they have a pale straw tint; small eyes may be placed in them entire, but large ones should be cut in two before immersion. After remaining during three or four days in this solution, the retina will be hard enough to allow sections to be cut sufficiently thin for study with $\frac{1}{25}$-inch object-glass. The usefulness of chromic acid lies chiefly in its hardening the retina well, with little alteration in the shapes of most of its elementary tissues, and enabling us to cut our sections in any given direction we choose—for instance, through the fovea, or tangental to it. But it has the disadvantage of distorting the elements by distending them, when the solution is too weak, or by shrinking them when it is too concentrated. It also renders them granular and proportionately opaque. Sections so prepared may be still stained with carmine.

Osmic acid is, in some respects, more useful than chromic. It was first brought into notice by Max Schultze of Bonn, whose labours have thrown much light on retinal histology. Solutions of from a quarter to a half per cent. are best. It not only blackens the transparent nervous tissues, making them distinct, but it enables us, with a couple of fine needles, to split the retina in vertical planes, which afford us beautiful sections much thinner and clearer than any that the most practised hand can cut with the sharpest knife. Another advantage is, that it does not make the tissues so granular as chromic acid; but it has this drawback, that with it we cannot run the section in any direction we choose. It is of greater service in those vetebrates whose retinæ are devoid of blood-vessels, because their presence seriously interferes with clean cleavage. The retina, stained and hardened by osmic acid may be kept for use in distilled water without undergoing any further change during several weeks. It is best mounted in glycerine for microscopic examination.

To return from this digression to the description of the retinal layers; in the outermost or bacillary there are two sorts of elements, distinguished as *rods* and *cones*.

Every rod and every cone consists of two segments—an outer one, the bacillus or shaft; and an inner one, the appendage or body. The shafts of both rods and cones are highly refracting conspicuous

microscopic objects; whilst the appendages are pale, have a low refractive index, and are less evident.

The inner and the outer segment are separated by a sharp transverse line, where the slightest violence snaps them asunder.

The rod-shaft is a long, slender cylinder—in profile, a narrow rectangle. The ends are truncated; the outer rests on the choroidal epithelium, and the inner joins the appendage. In the perfectly fresh shaft I cannot discern any differentiation of parts, except an external outline, indicative of a containing membrane, and a homogeneous contained substance; but very soon after death the shafts begin to alter. The fresh perceptible change is, I think, a very faint longitudinal striation, and this is followed by the appearance of cross lines, which divide the shaft into light and dark segments; at the same time the shafts swell and bend and lose their rectilinear figure. This segmentation, which must have been familiar to every one since Hannover first wrote on the retina, I have never seen in absolutely fresh shafts examined instantly after death; so that, in common with others, regarding it as a *post mortem* change, I did not attach much importance to it. Professor Schultze, however, has founded upon it the ingenious view that the shafts are built up of discs of alternately nervous and connective substances.

The inner segment or rod-appendage has commonly the shape of a slender triangle or spindle; and one of the outer granules, as I shall shortly show, is always associated with its inner end. In its outer end, immediately inside the line which marks it off from the shaft, there may often be seen, particularly in the large rods of amphibia, a small hemispherical body of the same refractive index as the shaft to which it sometimes remains attached when the shaft and appendage separate. It was long ago described by the late H. Müller, whose loss every histologist deplores, and I figured it myself in a communication to the Royal Society in 1862. Schultze, who has lately called attention to it, suggests that it may act as a collecting lens.

The outer segment of the cones—the cone-shaft—is usually shorter than the rod-shaft, and it commonly tapers slightly outwards, the outward end being slightly narrower than the inner. The cone appendage is usually flask-shaped or bulbous; and, like the corresponding part of the rod, its inner end always has its associated "outer granule." In the outer end of the appendage in birds, in some reptiles, and in batrachians, lies the well-known coloured bead which forms so exquisitely beautiful a microscopic object in the retina of these animals.

The interstices between the bacillary elements are occupied by a soft, homogeneous connective substance, which in all vertebrates below mammals contains a granular pigment. This extends inwards from the choroidal epithelium around and between the shafts as

far as their line of union with the appendages. It completely insulates the shafts, and would have the effect of absorbing any pencil of light which, making a relatively small incident angle, might escape laterally outwards through the shaft-wall, and in this way the escaped pencil would be prevented from entering a neighbouring shaft.

In mammals, the greater slenderness of the shafts probably renders such a provision unnecessary, because the incident pencil, to enter the shaft, must nearly coincide with its axis; and, as regards the side of the shaft, the angle of incidence would be so large that the pencil would probably be totally reflected.

The inner ends of the rods and cones pass through apertures in the connective membrane, called the membrana limitans externa retinæ, and are produced inwards amongst the outer granules as slender bands or fibres. The membrana limitans externa is the sharp, hard line, always perceptible in vertical sections between the bacillary and the outer granule layers.

That the rods and cones are the percipient elements in the retina is now universally received, so that it needs hardly be mentioned; but it may be well to adduce the chief considerations on which this presumption rests. First, they alone of all the retinal tissues are so arranged as to be capable of receiving separate and distinct stimuli from small incident pencils of light. Next, their absence entails absence of perception. Mariotte's experiment proves this as regards the optic nerve disc, and the increase of the size of the blind-spot in myopia from posterior staphyloma, proportionately to the extent of the white atrophic crescent—a fact which is easily roughly verified—is another proof of the same thing; because here, together with the disappearance of the choroidal epithelium and chorio-capillaris, I have had opportunities of proving microscopically the absence of the cones and rods.

When we endeavour to press our inquiries farther, and try to ascertain what may be the respective functions of the outer and the inner segment of the rods and cones, and in what respect the functions of the rods and cones differ, we meet with difficulties which have yet to be overcome.

As regards the first part of this inquiry, the high refractive index of the shafts, and their insulation by a coat of pigment in many animals, points to a physical optical *rôle;* while the association of a nucleus (an outer granule) with the appendage, suggests a more vital dynamical share. If this be so, then the junction between the shaft and appendage marks the line where, so to say, the physical vibrations of light are converted into nerve-force.

Towards the solution of the second point of the inquiry, Schultze contributes the important fact that nocturnal mammals, as the mouse, bat, hedgehog, have no cones; and that in owls, they want

the bright orange and ruby beads of diurnal birds; and from this he conjectures that the cones may be concerned in perception of colour.

The *outer granules*, to which I must now pass on, are not minute, angular, solid particles, as their name implies, but cells or nuclei of very appreciable dimensions. Their numbers are directly proportionate to those of the rods and cones: and it is very probable—I may say certain—that each outer granule is associated with a rod or cone, and this in one of two ways. When the rod or cone-appendage is large enough to hold it, the outer granule lies inside the appendage in the plane of the membrana limitans interna, or at its inner surface; but, when the appendage is too slender to contain the granule, it is joined to the granule by a communicating fibre, the length of which is determined by the distance between the inner end of the appendage and the granule. In either case, the appendage is prolonged inwards in the form of a band or fibre beyond the "outer granule" towards the next stratum. This fibre I call the primitive bacillary fibre, or the primitive rod or cone-fibre, when I wish to distinguish it more particularly.

The *intergranule layer*, which, as its name conveys, lies between the outer and the inner granules, is a fibrous stratum. Some of its component fibres are nervous, passing between the outer and inner granules, and others are connective tissue. Of the latter set of fibres, those which traverse the layer vertically belong to the system of connective radial fibres, known by the name of their discoverer, H. Müller. The others, which extend parallel to the direction of the layer, constitute its proper substratum; and amongst these lie imbedded small nuclei, and in some of the lower animals, *e.g.* chelonians and fishes, large branched corpuscles of very considerable dimensions.

The *inner granules*, like the outer ones, are also cells or nuclei. According to their sizes, which vary much, they fall into two sets —smaller granules, everywhere numerous; and larger ones, most abundant near the inner surface of the layer, which I cannot distinguish from ganglion-cells. On the one side, the inner granules receive the fibres sent inwards towards them through the intergranular layer from the outer granules; and, on the other side, they send fibres inwards into the granular layer towards the ganglion-cells.

The *granular layer*, as Schultze correctly pointed out, is resolved, by a sufficiently high magnifying power, into a very finely fibrillated spongy web, which manifestly hangs together with, and is in great part a derivative of, the connective radial fibres entering it. The only nervous elements occurring in it are the internuncial fibres which traverse it, and the outermost ganglion-cells bedded in its inner surface. The term granular, which simply expresses its

appearance under a low power, is therefore preferable to that of grey vesicular or grey nervous layer, which gives a wrong idea of essential composition.

The cells of the ganglionic layer possess a very distinct roundish nucleus, imbedded in a pale and very soft protoplasm, about which there is not generally any distinct cell-wall perceptible. I believe that all the cells are branched. The outer branches, which are the more numerous, run outwards into the granular layer to join those coming inwards from the inner granules, while their inner branches join the bundles of optic nerve-fibres.

These last radiate in a plexiform manner from the optic nerve entrance. Where there is a fovea centralis, as in men, apes, some birds, and reptiles, the nerve-bundles are so distributed that those only destined for the fovea and its surrounding maculæ pass directly to it; while those bundles going to more distant parts beyond the fovea arch around it. With some exceptions, the nerve-fibres are devoid of medulla. In our own eyes, this ceases at the lamina cribrosa; and only pale fibres, equivalent to axis-cylinders, with perhaps an investment of the sheathing membrane, are produced into the retina.

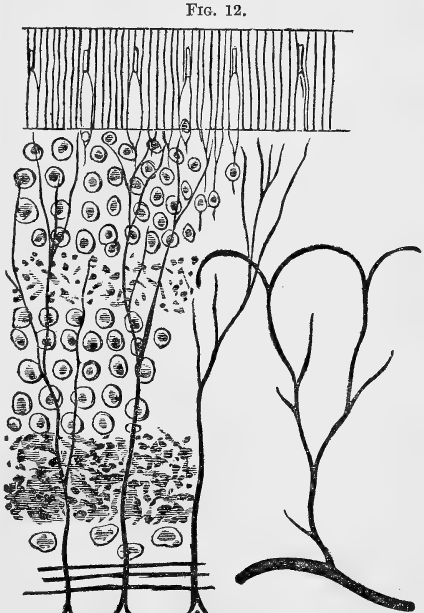
The connective-tissue frame, which supports and holds together the nervous elements, consists of three segments. First, there are the two membranes;—the outer limiting membrane, which I have already described; and the membrana limitans interna, which some identify with the hyaloid capsule of the vitreous humour, but which I regard as a distinct membrane. This distinctness cannot be always demonstrated at pleasure; but I believe it to be a fact, because I have found the two membranes separated by inflammatory effusions, and because in the eyes of a Burchell's zebra, for which I was indebted to the liberality of the Zoological Society, I found a beautiful pavement of epithelium on the outer surface of the capsula hyaloidea. The second member of the connective substances is a system of stout pillar-like fibres, which arise by expanded wing-like roots from the outer surface of the limitans interna, and traverse vertically all the layers in a direction radial from the centre of the eye-ball. These are the fibres which, when originally discovered by H. Müller, were believed by him to link the percipient elements on the outer side of the retina—the rods and cones—with the conducting optic-nerve fibres at the inner surface of the retina, an error which he himself was one of the first to correct. They form a frame, which mechanically binds together the several layers in their order. Lastly, the retina contains a large amount of interstitial connective tissue, which is accumulated in larger quantity between the inner and outer granules, and between the inner granules and ganglionic layer, but which also pervades, in smaller quantity, all the nervous layers except the bacillary.

Spinning an excessively fine web around the cells and fibres, it maintains them all in position, and it supports the blood-vessels when these are present. To sum up, the connective tissue occurs in three forms—membranous, as the membrana limitans externa and interna; fibrous, as Müller's radial fibres; and as an excessively finely-fibrillated interstitial web.

It is a remarkable circumstance that the retina in the greatest number of vertebrate animals does not contain any *blood-vessels.* A retinal vascular system is confined, I believe, to mammalia; and amongst these there are great differences in the distribution of the vessels. In man, the whole extent of the retina, from the optic nerve entrance to the ora serrata, is vascularized; and the same obtains, I believe, in the ox, sheep, deer, and antelope; while in the hare the vessels are restricted to the area of the opaque nerve-fibres; and in the horse they form a narrow zone around the optic nerve entrance.

In the human retina no capillaries penetrate farther outwards than the intergranule layer or the inner surface of the outer granule layer. In consequence of this arrangement, the rods and cones are nearer to the chorio-capillaris than to the retinal capillaries. This alone would make it probable that they derive their nourishment from the capillaries; and morbid anatomy abundantly confirms this, for it is an established fact that atrophy of the chorio-capillaris, entailing atrophy of the hexagonal pigment epithelium, is also followed by atrophy of the rods and cones.

Fig. 12.



Vertical Section of Retina, to illustrate the Distribution of the Vessels.

In the common hedgehog I have observed a peculiar disposition of the vessels, which is intermediate between the typical distribution in man and most other mammals I have examined, and that which obtains in the lower vertebrates; *viz.* the larger vessels, arteries, and veins, channel the capsula hyaloidea, while capillaries only pierce the retina.

In fish, batrachia, and reptiles, the vascular net which pervades the capsula hyaloidea represents the retinal vascular system of mammals, but in birds this hyaloid net is wanting; and the great development of the pecten was thought by Müller to be a compensatory provision for both its absence and that of retinal vessels.

I will now pass on to notice—and I can only do so very briefly—the characteristic modifications which the retinal elements undergo in the five vertebrate orders.

In *Fish*, the retina is distinguished by the occurrence of cones of a peculiar kind—double or twin cones, as they are commonly called—by the large quantity of connective tissue it contains, and by the presence of very large branched connective tissue corpuscles in the intergranule layer.

The twin-cones have distinct outer segments or shafts. Their symmetrical appendages are joined together down one side, and at their inner end they sometimes appear to be actually continuous. Each twin has, I think, its own outer granule, and detaches a separate fibre inwards.

The *Batrachian* retina is distinguished by the large size of its elementary tissues: the rods are very large. The cones, which are smaller, contain a pale yellow or colourless bead. Twin-cones have been discovered in it by Schultze.

Amongst *Reptiles,* lizards possess cones only; these contain a pale yellow bead (in all I have examined). They are single and twin; but the twin-cones differ in many respects from those of fish. They are unsymmetrical in form, and one is beaded while the other is beadless. Their union is much less intimate than that of the fish's twin-cones. A little violence frequently disassociates them.

The chameleon, iguana, gecko, and many other lizards, have a fovea centralis, from which the primitive bacillary fibres radiate towards the periphery of the retina, and pursue an oblique course from the outer towards the inner surface of the retina, crossing the vertical radial connective tissue fibres, which enables us easily to distinguish the nervous and connective tissue fibres in this region.

In many lizards, a well-developed, conical, or sword-like pecten stands forwards from the optic nerve in the vitreous humour towards the lens. In the common alligator, and in the Nile crocodile, there is no projecting pecten, but the optic disc is marked with a brown pigment.

The blind worm's retina closely resembles that of typical lizards, especially in the presence of a pale cone-bead.

A cone-bead is wanting in snakes. In other respects, their retina resembles that of lizards.

The common English snake has no pecten: the viper has a rudiment of one; and the boa's optic nerve has a minute globular one.

The *Chelonian* retina agrees very closely with that of birds. Both are distinguished by bright cone-beads, and by twin-cones, the structure of which, particularly in chelonia, resembles that of lizards, and differs in the same way that this does from that of the fish's twin-cone. Each twin has certainly its own outer granule, and its separate primitive cone-fibre, which, as in lizards, takes an obliquely radial direction from the posterior pole of the globe. The cone-beads are of three colours—ruby, which are the largest; and orange, passing through pale yellow into pale green: the orange and green beads are the most numerous. The intergranule layer contains large branched connective tissue corpuscles, resembling those occurring in the same layer in the fish's retina.

The *Bird's* retina, as I have just said, agrees in several particulars with that of the chelonia. It has cones with beads of three colours, except in the case of nocturnal birds, *e. g.* owls, in which, as Schultze first showed, all the beads are pale, almost colourless, a light yellow. It has also twin-cones, like those of reptiles. In many birds there exists a very distinct fovea, and in some H. Müller discovered two, one at the posterior pole and the other near the ora retinæ, the former being affected by the incident pencils in monocular vision, the latter coming into use in vision with both eyes. The primitive bacillary fibres radiate obliquely from the fovea, as in man and reptiles.

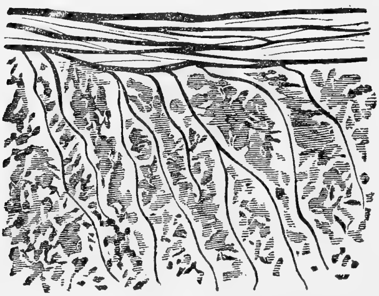
The *Mammalian* retina is marked by the absence of twin-cones and of cone-beads. Its elements are smaller than those of the lower vertebrates. That of man has a macula lutea, in which is a distinct fovea centralis. The macula lutea occurs also in certain apes. The bat, mouse, hedgehog, and certain other animals, chiefly of nocturnal habits, have rods only; in most others cones and rods are both present, as in man. The retina is vascular; the distribution of the vessels, however, varies in different families.

There are two situations where the structure of the retina in man and some other vertebrates which I have particularized is peculiar; these are the macula lutea and the ova retinæ. The macula lutea is an oval spot, at the posterior pole, of a yellow colour: the coloration is not produced by granular pigment, as in that of the choroid, but it is a diffuse stain of the elementary tissues. In the centre of the macula is the minute pit—not a perforation—the fovea centralis. This pit is produced by the radial divergence of the primitive cone-fibres from a central point, and by the thinning and outward curving of all the retinal layers (except the bacillary) as they approach this point. In the fovea and the macula, except at its periphery, cones only occur, and they are more slender and longer than in other parts of the retina. The greater length is chiefly due to the elongation of the cone appendage. The slenderness of the cones does not allow their appendages to include the

outer granules, so that these latter lie, all of them, at the inner side of the membrana limitans externa. Owing to the radial direction of the primitive cone-fibres, the outer granules belonging to the central cones lie peripherally, so that the outer granular layer is absent from the foveal centre.

At the inner surface of this layer the cone-fibres combine in a plexus the bundles of which, near the centre of the macula, are directed obliquely towards the inner surface of the retina; between the centre and the circumference of the macula they assume a direction nearly parallel to the retinal layers, and at the circumference of the macula they run nearly vertically.

Fig. 13.



Primitive Bacillary Fibres, from the innermost Bundles of the Cone-fibre-plexus, traversing the Intergranule Layer.

At its inner surface, the cone-fibre-plexus breaks up into primitive fibres, which pass through a thin connective tissue stratum, the intergranule layer, and enter the inner granule layer. This latter, at its beginning in the centre of the fovea, is not separate from the ganglionic layer. The nerve-fibres pursue in it the same direction as in the outer granule layer.

The ganglionic layer, at the periphery of the fovea, contains three or four tiers of cells; these become fewer towards the foveal centre, but even here they lie in a double or treble series, bedded in a granular tissue.

The ora retinæ is the other situation to which I referred as having a peculiar arrangement of its tissues. Being less important than the fovea, I can notice it only very briefly. Towards the ora the nervous elements gradually become fewer, the layers thin out, the beads and cones shorten and become stouter. With this decrease of the nervous tissues, the connective tissues predominate, and they are prolonged beyond the ora as the pars ciliaris retinæ, the radial fibres becoming, according to Kölliker's observations, the columnar, epithelial-like bodies which line the pars striata.

III.—*Experiments on Spontaneous Generation.* By EDWARD PARFITT, Curator of the Devon and Exeter Institution.

LIFE is one of the great problems that has engaged the attention of the most profound thinkers and writers of both ancient and modern times. In our own time this problem seems to have excited more to investigate its mysteries than that of any other period of which we have any record, and more experimental philosophers have entered the field now than at any other time; and even now philosophy and chemistry have failed to explain what that wonderful *vis vitæ* really is.

It is the opinion of one or two of our philosophic naturalists that the distance between them and the vital spark is gradually becoming less; that they are, in fact, enclosing it within a wall of argument and experiment, and that at last it must yield to their investigation.* "But even if it could be shown that the chemical actions that go on in the organism are no other then what can be imitated in the laboratory, it would still be certain that life is not a mere resultant from any physical and chemical forces, and that there must be a distinct vital principle."

It is the opinion of some that the act of crystallization and the *vis vitæ* or vital force are one and the same thing. In this I cannot agree. There appears on the surface a great similarity, I admit, and the laws which govern the formative process would appear to be identical; but having arrived at the ultimate form in crystallization, there the matter stops. On the other hand the case is very different in its results; for an animal or plant, be it ever so low in the scale, is each endowed with a property peculiar to an organized body; namely, that of reproduction.

This, then, at once separates the organic from the inorganic kingdoms. The perpetuation of the vital principle as compared with the highest forms of crystallization, and which, so far as we know, we may term the ultimate, is to my mind separated at once and for ever by the perpetuation of the vital principle.

Buffon imagined life-like matter to be indestructible, and that each organism was built up of a number of molecules, and that each molecule had a life of its own, and the death of one of these complex compounds was simply the dissolution of one of these associations; and thus he says, these molecules are again set at liberty, and wander about until they are once more combined with an animal or a plant; and as Coleridge has beautifully said—

"Organic harps are living things,
That tremble into thought,
As the one breath sweeps o'er their strings,
The mind that has them wrought."

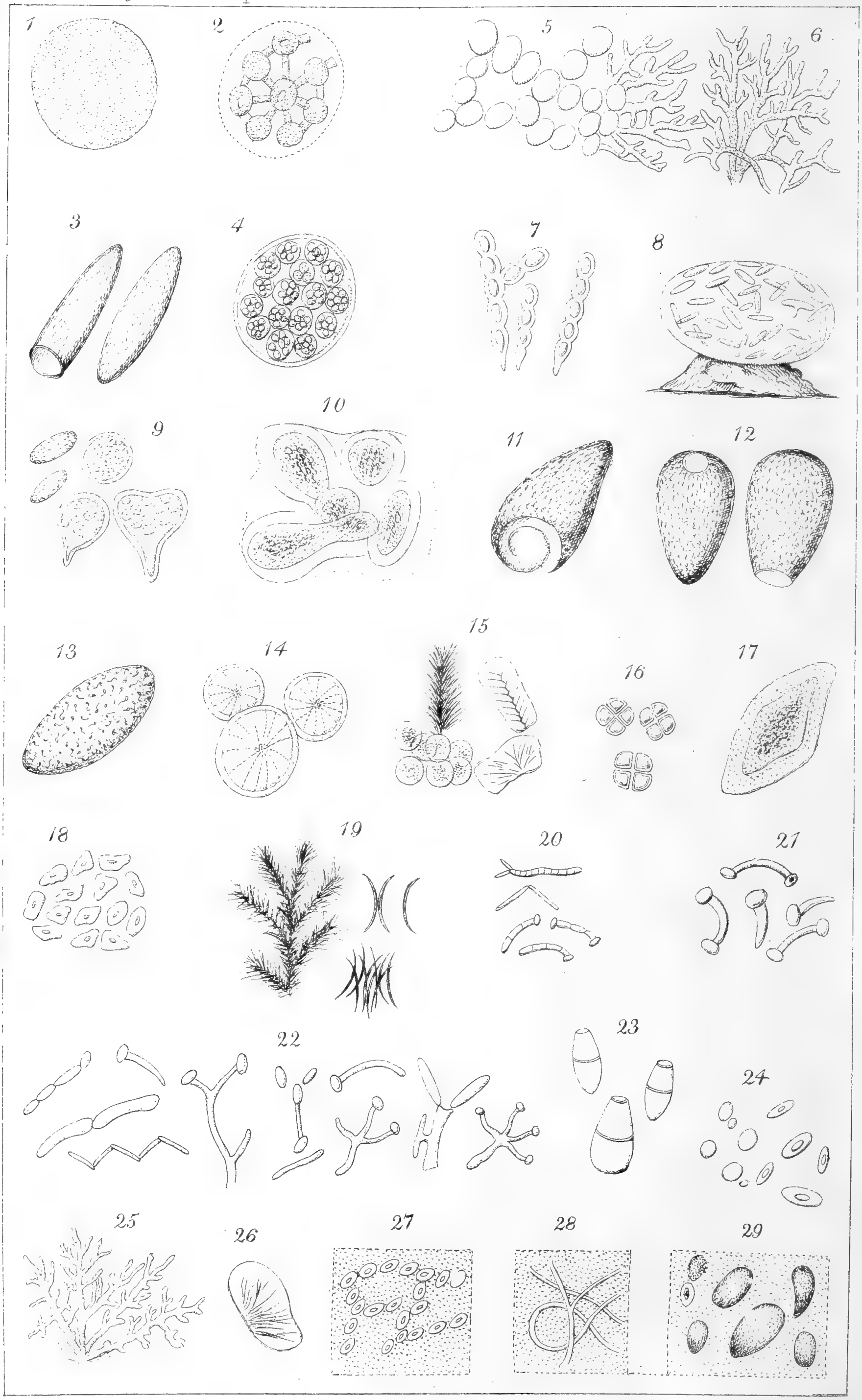
* Murphy: 'Habit and Intelligence,' vol. i., p. 88.

Spinosa, who held a rather different opinion to that of Buffon, believed that there is in nature only one substance, and that this substance is infinitely diversified, having within its one essence the necessary causes of the changes through which it goes.

In the investigations into the development of life, and to which the title of *Spontaneous Generation* has been given, I desire to direct special attention. We have in this something similar to that to which Buffon alludes when speaking of "the wandering molecules." For when the portions of the organisms have become disintegrated or broken down, the molecules and cells of which they were formed are set free, and it is to the study of these in their separate and also in their aggregate forms that I desire to direct attention. A molecule is believed to be an aggregation of atoms; and it is only in the molecular form that we are able to recognize matter in its highest state of disintegration; and although we are enabled to examine with our instruments the apparently extreme points of matter, yet there is a world which lies beyond, as yet invisible—the "atomic." One of the most recent and apparently one of the best informed philosophers in treating of this subject—the "atomic theory"*—Professor Bayma—believes each atom to be spherical in form, and surrounded by a repulsive electric ether, the atom itself being attractive; and that every point of matter acts instantaneously upon every other point at all distances, however great or small, with a force having the same character at all distances, and inversely to the square of that distance. But I hold with Professor Norton that this is assuming too much, as no proof has been established that an atom is spherical in form, or that it is a material point. "In fact, it appears to be highly probable, as supposed by Brodie, and strongly urged by Gerhardt and his followers, that few if any elementary substances in their uncombined condition are really known to us; the so-called elementary bodies being really compounds of at least two atoms of the true element with each other. Thus hydrogen gas is not simple hydrogen, but is H_2, or $\frac{H}{H}$, hydride of hydrogen, and so on with others."†

We set out, then, as Mr. Herbert Spencer ‡ says, "With molecules one degree higher in complexity than those molecules of nitrogenous colloidal substance into which organic matter is resolvable; and we regard these somewhat more complex molecules as having the implied greater instability, greater sensitiveness to surrounding influences, and consequent greater mobility of form. Such being the primitive physiological units, organic evolution must begin with the formation of a minute aggregate of them—an aggregate showing vitality only by a higher degree of that readiness to change its form of aggregation which colloidal matter in general

* 'Philosophical Magazine,' 1869. † Miller's 'Chemistry,' vol. iii.
‡ 'Principles of Biology,' vol. 2, p. ii. 12.



E. Parfitt del. Tuffen West sc. W. West imp.

Products of spontaneous (?) Generation.

displays. A further stage of evolution is reached when the very imperfectly integrated molecules forming one of these minute aggregates become more coherent, at the same time as they pass into a state of heterogeniety, gradually increasing in its definiteness."

Dr. Winslow,* in speaking of the forces exerted upon molecular matter, says, "In whichever light we study the action and reaction of these binary elements of mechanical energy, or *vis*, we observe all the phenomenal results in crystals, plants, or animals to develop themselves upon crucial and bilateral principles, and all the secondary forces to follow the same axial and equatorial lines of propagated molecular force and motion."

This is exemplified in a remarkable manner in the molecular movements in all the experiments that I have instituted. We first observe a homogeneous molecular mass (Plate XXXII., Fig. 1) floating or suspended in water, which has been added; and almost as soon as the infusions have become cold we observe a remarkable movement has taken place with the molecules; part of this is, I presume, from the loss of heat. They have already begun to form themselves into some definite shape (Fig. 2). There have, then, been forces at work imperceptible to us, except that we see the results of those powers in the formative process that is going on. The same, or apparently the same, formative process may be seen, I admit, in the act of crystallization, as the suspended molecules are drawn towards each other by a force that is termed affinity or attraction; but when the crystal is formed, the process is complete. This same process may be repeated by the addition of other and similar crystals, but this is all; here crystallization ceases; it can go no farther. The same laws that govern both organic and inorganic matter, when each are placed in similar conditions, appear to act the same on both; the same influences are exerted on both, and apparently in the same degree; indeed, the two seem to run in parallel lines to a certain distance; at last the inorganic stops; it has reached its ultimate form. Its hitherto companion is still acted on by the same forces: it is carried forward, and here the true *vis vitæ*, or life-force, is really seen. We now see distinctly the difference between the organic and the inorganic kingdoms. When the two started, we saw what we believed to be the same energy acting equally alike on both—the *vis* or force, the *vitæ* or principle of life, had not then manifested itself.

But the very fact of life being transmitted or carried forward implies a force or energy. At the same time it is not a mere mechanical force, such as we saw at work in the formative process of crystallization, but a life-force, a force that implies that some other and peculiar property is bound up with these mechanical forces.

* 'Force and Nature,' p. 282.

"Force so combined with force as to produce certain definite and orderly results: this is the ultimate fact of all discovery."*

Mr. Browning, in 'Transactions of the Royal Microscopical Society' for July 1, p. 18, says:—"There are probably some grounds for believing that the particles or molecules in magnets are always in motion;" and, he says, "Mr. Wenham once told him that he had seen a cavity in a crystal partially filled with a fluid, and for several years this fluid had been unceasingly in motion, although completely shut off from the surrounding atmosphere. Motion, then," he says, "is not peculiar to life; and we shall be brought at last to the single distinction—reproduction." In this I fully concur, as I had arrived at the same conclusion, as before stated. Mr. Browning goes on to say, curiously enough, in the very next sentence, that what he had just approved is not true, and cannot be accepted; for, he says, "The difficulty here would be insuperable, if we were compelled to accept the hypothesis that life is transmitted from one organism to another. But this hypothesis is no longer generally accepted. Professor Owen, who has been until recently opposed to such views, has at length accepted the hypothesis of spontaneous generation." This passage, I think, would puzzle a Philadelphia lawyer.

The term "spontaneous generation," although it expresses a certain meaning, I think is not admissible; although we see things apparently springing into life where no life appeared to exist, yet in a few hours every molecule is a moving, living body. In this light it seems to me more like suspended animation; and that every molecule, directly it is set free, is seen dancing about in the infusion, like gnats in the sunbeams, and apparently as full of the enjoyment of life. And it would also seem as if an organism was composed of an infinite number of these, and that, when set free, they returned to their original conditions; for the great variety of both animal (or what we believe to be animal) and vegetable forms, which are developed in a single infusion of either animal or other organic matter, would almost warrant us in believing such to be the case; but at present it would not be prudent to venture so far.

Again, when we examine our infusions, whether they be made with vegetable or animal, we detect life, or what we believe to be life (and not mechanical force), in the most minute points or molecules that our instruments enable us to observe; and why I believe this motion to be life is, that we see the molecules in different stages of development. At the same time I am fully aware that motion does not distinguish an animal from a vegetable, as many plants are endowed with that property.

The most minute and searching microscopic investigations have availed us but little in the elucidation of the mysteries of life. One

* Duke of Argyll: 'Reign of Law,' p. 81.

great thing it has done for us, and that is this, it has opened up a vast field of research, and carried our knowledge into infinitesimal matter, in which it thins away until it seems to vanish into thin air, and yet as far as the eye can see does life reside. The minute cells of which both plants and animals are built up, the very petals of the flowers, and the eyes of the human subject, are swarming with life, not their own, but myriads of independent creatures, so that at last we are almost forced to accept the words of Buffon, as referred to in the first part of this paper.

Thales supposed all things to be generated out of water; and in this he was not far wrong, as the beginning of life, so far as we are enabled to appreciate it, is mainly dependent on a certain state of humidity for its existence. Amongst the protophytes, or simplest plants, there are many of which every single cell is not only capable of living, but may be normally considered a distinct plant. For instance, observe the beginning of a lichen on a newly-hewn stone. It will there be seen to spring from a single cell, and this cell, should the condition of humidity continue favourable, will very soon develop others, so that in a short time a thin stratum of cells may be observed radiating in all directions.

In the infusion of the liver of a fowl, and to which I shall again have to refer, I observed on my first investigation, eighteen hours after the infusion was made, a number of bluish elliptical cells, very much like the spores or cells of a *penicillium*; these had the power of propagating or continuing their like by a kind of gemmation, that is, the inner walls of the cells appear to develop minute gemmæ, or little buds, which spring into cell-life; and it frequently happens that one single cell may contain many generations of cells, as they are graduated down to extremely minute points, and at length lost to view. These cells propagate very rapidly, forming themselves into long moniliform masses. Now the difficulty is how to account for these cells in this infusion, as I had done all that I could do to destroy life, by boiling the liver until it was all, or very nearly all, broken down or disintegrated, so that it appeared only as a molecular or flocculent mass. These cells measured about $\frac{1}{12000}$th of an inch long. My impression is, that these cells were embedded in the flesh of the liver, as I do not believe them to have been admitted through the agency of the atmosphere into the vessel. Every provision was made to make the experiment as perfect as possible.

Dr. John Lowe* mentions the case of peculiar cells being found in the lungs and kidneys of a man. These cells measured $\frac{1}{10000}$th of an inch, which correspond very nearly with the size of those found by me in the liver of the fowl. I do not agree with M. Pasteur in ascribing to the agency of the atmosphere the various vegetable

* 'Edinburgh New Philosophical Journal,' 1860.

cells that have been found in the numerous infusions that have been made in the investigations of this so-called "Spontaneous Generation;" for although I have studied fungi for at least twenty years, I have never found them so abundant as to fill the atmosphere so completely with sporules as some would have us believe, and that at all seasons of the year, and in every condition, in the still atmosphere of a room equally with that in the open air.

The extreme difficulty of destroying life I have found in every experiment, for neither baking nor boiling will destroy it; these may change the form and outward condition of the things operated on, but you cannot drive life entirely out of it by either of these processes.

The greatest heat that has been applied to experiments of this kind is 200° centigrade, or 500° Fahrenheit, and even then, says M. Pouchet, animalcules and fungi are developed. "Neither calcined air, sulphuric acid, liquor potassæ, gun-cotton, nor a boiling temperature have prevented the production of infusoria, or destroy the supposed germs in the air or infusion."*

If we take the case of *sarcina ventriculi*, as found not unfrequently in the human stomach, and also the vegetable sporules found in the kidneys; the temperature of the stomach averages about 98°. Again, take plants, such as *ulva thermalis* and others, which live in the hot springs. But it may be said that these plants are adapted to places in which they are found, and it is consequently natural to them. Be it so. But still it shows us that a heated medium is not antagonistic to vegetable life. M. Pasteur says, that the boiling temperature, that is, 100° centigrade, does not prevent the growth of the germs in the atmosphere; but, he says, that 130° centigrade always destroys their vitality. This, it will be observed, is directly opposed to the experiments instituted by M. Pouchet, as before stated, that the temperature of the infusions may be raised to 200° centigrade, and yet animalcules and fungi are developed.

There is one very remarkable thing to be observed in all the experiments that I have prosecuted, and that is this, that all the larger and stronger plants, if I may call them so, have sprung from the oil-globules. This may be said to be in favour of M. Pasteur's argument, that the germs are admitted with the atmosphere; and as the oil, being lighter, generally floats on the surface of the infusion, the germs are first brought into contact with it; and finding a proper and rich medium in which to vegetate, they rapidly spring into life, the result of which we see in our microscopic examinations of the infusions. This, although it appears so favourable to M. Pasteur's hypothesis, is not true in the main; for I have carefully examined other parts of the infusions, and particu-

* Dr. Hughes Bennett, in 'Popular Science Review,' January, 1869.

larly the flocculent matter, which also contains oil-globules, and which is generally held in suspension, and floats near the bottom of the infusions, to be equally abundant in vegetable organisms as those masses which float on the surface; and in the case of the liver of the fowl, a small portion which remained entirely at the bottom of the vessel developed one of the largest growths that I have yet seen, and which I believe belongs to the genus *Leptomitus*, and is very nearly allied to *L. lacteus*, but it differs from that species in not being constricted at the joints. Again, on this same piece of liver arose a rather large inflated film, or what appeared to me a protoplasmic or structureless thin jelly; this never was brought into contact with the air at all, except when I took up a portion of it with a glass tube, to place it under the microscope; and yet this film had embedded in it quite a network of illiptical sporules, not molecular bodies, but having all the appearance of sporules of some mucorinous plant. This, then, to me, who saw this remarkable structure, would prove a great stumbling-block to the acceptance of M. Pasteur's theory. This structure appeared on the eighth day after the infusion was made (Fig. 8).

I began my experiments in this way: I prepared three glass vessels by thoroughly cleansing them and boiling them; I then dried them at the fire. I then took part of the liver of a fowl directly from the bird, and placed it in one of the vessels, covering it instantly it was taken out; I then poured about two inches of boiling water into it, keeping it covered, except when the water was being poured in. I then took a piece of beef, of about half-an-ounce in weight, cut directly out of a larger piece, so that it should not be brought into contact with the atmosphere more than was possible, and placed this in the second prepared vessel, keeping this covered as before. I then took a saucepan half-filled with water, into which I placed two of the vessels, keeping them carefully covered all the time with stout paper covers, leaving a long curtain of paper reaching half-way down the vessels, so that what air got into the vessels must make a circuitous route. I then boiled the contents of the vessels for fifteen minutes, when the liver had nearly all become disintegrated, and the beef had begun to break down, and was giving off masses of flocculent matter, both making a more or less coloured infusion. Night having intervened between the boiling and the examination, but at nine o'clock the next morning I found each infusion tolerably clear, the colouring matter having become deposited at the bottom, and each infusion was covered with a thin pellicle, which was filled with minute points of the disintegrated liver. The molecules of the liver were, as a rule, smaller than those of the beef; but in the liver I observed, beside the molecules, some larger bluish-looking cells, about $\frac{1}{12000}$th of an inch long; I also observed a few in the beef (Fig. 2). The molecular

mass in the pellicle of the beef infusion had already begun to assume a definite form. (See Fig. 2.) After this I saw no great change in this, except that it followed closely in the wake of the transformations of the molecules of the liver, and which will now claim our special attention. The contents of the third vessel, which contained an infusion of fish, will be alluded to farther on. On the third day the principal portion of the molecular mass had arranged themselves into long tubular lines, the tubes being formed of a very thin transparent film (Fig. 3). This protoplasmic and structureless substance is very remarkable, and is found in all the infusions that I have as yet had under experiment, and in this the greater part of the molecules are seen to be imbedded; and it appears to me that this is what is acted on by the forces before mentioned, and which becomes moulded into the various forms that more or less approach some of the recognized animalcules.

The substances which we are discussing appear to me to divide themselves naturally into four divisions; thus, first we have the molecules; secondly, we have the structureless substance; thirdly, we have the oil-globules, or cells; and, fourthly, we have what appear to be vegetable cells, or spores of some mucedinous plant. The latter were so distinct that it would be impossible to confound them with anything else seen in the infusions; and from their being found in the flocculent matter, and also imbedded in the film, as seen attached to the piece of liver at the bottom of the vessel, I do not believe them to be obtained from the atmosphere. On the fourth day the oil-globules were very numerous, and varying from $\frac{1}{1800}$th to $\frac{1}{12000}$th of an inch in diameter, each having a double wall; the interior was entirely filled with what appeared in the smaller cells to be a grumous mass, but the larger cells showed what this really was, namely, a mass of cells, and these again were filled with smaller cells, and so on, until they were lost to view (Fig. 4); so that one large cell contained many generations of cells.

The next day these larger cells had burst, and their contents had formed themselves in long, moniliform, decussating lines (see Fig. 5), and from a group of these I observed another, and quite a distinct growth, had sprung, agreeing in the manner of branching to a plant I shall next have to mention. The mycelium-like threads measured about $\frac{1}{6000}$th of an inch in diameter, and they had just the appearance of the mycelium of some fungus. I tried to find the nucleus or spore from which these mycelia had sprung, but I could find none. The only thing I observed was, that they appeared to me to spring from this group of cells. Both these groups of cells had a yellowish-blue colour, I presume from the refracted light.

On this same day (the fifth) of the experiments there appeared at the bottom of the infusion of the liver a remarkable plant (Fig. 6).

It sprang from a small piece of liver lying at the bottom of the vessel. This grew from a very small speck when first observed to six lines in height by the seventh day. The filaments of which the plant is composed are hollow, and with the highest magnifying power I could apply I could observe no cellular structure. It branched in a dichotomous manner, and the tubular stems were filled more or less with a grumous mass, very thick towards and at the base, but gradually lessening in mass and density upwards, so that the apical portion of the main and lateral branches appeared free and transparent. The diameter of the principal branches was about $\frac{1}{2000}$th of an inch in diameter. This plant grew very rapidly until it nearly reached the top of the infusion, and at this time I clearly saw that it belonged to the genus *Leptomitus*, and that it was very nearly allied to *L. lacteus*, only that it was not constricted at the joints or septa. I shall name this plant provisionally *Leptomitus ktisma*. On the 12th day it had reached the top of the infusion. The exposed portion turned to dull pale olive green, and reflected a bluish tint, and when I took some of it up to examine it, the portion so taken seemed to me to be entirely alive with moving elliptical bodies, measuring from the $\frac{1}{18000}$th of an inch long, and graduating down to the most minute point. These were exceedingly active, moving about in all directions. When seen singly they appeared of an opaque white, but seen *en masse* they had a pale olive-green colour. I observed that here and there one might be seen longer than the others, as if two or more had become fused together. These would all of a sudden start off across the field of view, driving any that might happen to be in their way aside; and when they had full room to move, would swim with a whirling or gyrating motion.

On the sixth day I observed a curious growth, apparently springing from one of those bluish-looking sporules before mentioned. These have somewhat the appearance of some of the asci of the genus *Peziza* or *Ascobolus*—compressed, clavate, but constricted between the sporules, the fronds measured $\frac{1}{6000}$th of an inch long. I only saw this one group, and therefore cannot say what it really is. It is probably a plant in an incipient form, but I know of nothing like it amongst British plants (Fig. 7).

The eighth day revealed a very curious and interesting development; not exactly a plant, but a number of elliptical cells appeared imbedded in an inflated bubble, caused, I presume, by the generating of some gas from a piece of liver lying at the bottom of the vessel: the rest of the liver was also covered with a film protoplasmic substance. These cells were very evenly scattered over the bubble (Fig. 8). A few of them had united and become more elongated, and one or two had either had others attached and become fused together, or a long cell had thrown out a short branch at right

angles to the larger or parent cell. The average length of the single cells was about $\frac{1}{6000}$th of an inch long. How these cells had become imbedded so evenly in this film, or how they came there at all, at the bottom of the infusion, I cannot imagine: I do not believe in their having come from the atmosphere. The surface pellicle at this time was swarming with the so-called *bacteria* and *vibrios*, in different stages of development.

From this up to the fourteenth day I observed no particular change, but now the vibriones had become much elongated, similar to those figured by Dr. Hughes Bennett, in 'Popular Science Review,' page 53, Fig. 2.

The beef infusion had at this time developed plenty of *bacteria* and *vibriones*, and three large patches of *Penicillium crustaceum*, which occupied nearly all the surface of the fluid, but no other plants were observed in it. This plant did not make its appearance at all in either of the other vessels.

Fifteenth day the pellicle of the liver showed several dense patches of cells, varying very much in size, and of various forms, the smaller ones being generally spherical, and the larger ones more or less angular, the larger being filled with cellules in various stages of development. This was almost the first bright or sunny morning since the commencement of the investigations, and the *vibriones* were exceedingly active, moving about in various directions, and gyrating, reminding one very much of the gambols of *Gyrinus natator*.

Sixteenth day I observed imbedded in some flocculent matter of the liver, suspended near the bottom of the vessel, some curious cells, very much like the nucleous bodies found in the sarcode of Gromia, as figured by Schultze and Carpenter. The large cells were filled with a molecular mass, in various stages of development into cellules. In the large pedunculated cells it will be seen that the molecules have arranged themselves somewhat into lines, particularly towards the peduncle, and gradually developing upwards into cellules; the lines of demarcation could be just discovered (Fig. 9). In the spherical cell these lines were rendered more distinct, the cell having apparently reached a higher state of development. The development of cell structure from the molecular mass was seen to great advantage in these large cells, better perhaps than from the larger masses of molecular matter. We first observe the enclosed molecules are being acted on by some force or forces as they begin to arrange themselves into various groups, drawn together into centres, and consequently the lines between these centres are rendered clear and transparent, and from these it would appear that the protoplasmic film grows, and envelops the nucleus of molecules. In a short time the molecular mass in these enclosed cells also begins to divide in a similar manner. So the development goes

on, dividing and subdividing, and at the same time the continuation of life.

The 17th day was cold and dull. I could not discover anything different from what I had seen before.

On the 18th I observed some of the highest developed forms that have yet been discovered, either by M. Pouchet, Dr. Hughes Bennett, or, so far as I have seen, any one else. M. Pouchet describes this, or a form figured by him which I take to mean the same thing as this, to be the ova of *Paramecium*. At first I observed a number of groups of molecules collected together into various shapes, and some appeared in the act of dividing, or as if a larger and a smaller had joined together (Fig. 10). Each of these groups was enveloped in a proligerous membrane, and at a little distance from this was to be seen another membrane, and these again were attached, or rather imbedded, in another free one, which outer one was thickly studded with molecules of matter, and the whole infusion was swarming with vibriones, which appeared larger than I had before seen.

We now come to some remarkable forms, which appear rather more advanced than those figured by Pouchet, and copied by Dr. Hughes Bennett;* but if they be the same, only in a different position, I have found that what Pouchet took to be a nucleus is in reality an orifice. In this case they would come very near to, if not identical with, *Prorodon niveus*; but these are more pyriform. But I could not detect the toothed mouth, or the polygastric system (Figs. 11, 12). These organisms were constructed of the protoplasmic film, thickly studded with molecules, which latter were rather larger than the generality, and were more sharply defined. It will be observed that the orifice of one of the specimens is at the larger end, whereas in the others it is at the smaller end. These specimens measured about $\frac{1}{16000}$th of an inch in their widest diameter. One specimen I observed quite different from the rest. The protoplasmic film had rolled itself round a long axis, and formed an orifice very much like the genus *Stentor*, and which this specimen also reminded one of in its elongated form (Fig. 11). The molecules imbedded in the film forming this organism were arranged, more or less, in longitudinal lines. This measured $\frac{1}{5000}$th of an inch in its widest diameter, by $\frac{1}{10000}$th of an inch long. I could not discover any movement in these, either ciliary or otherwise.

On the 20th day we arrived at the highest development in the direction of animal life that I have been able to obtain; that is, if we except some very remarkable vibriones that I observed on the 38th and 44th days. This, as will be observeed, is a hollow ellipse, and is formed of the protoplasmic film, and is rather sparsely studded with what appeared like very minute tadpoles (Fig. 13). This

* 'Popular Science Review,' fig. 5, p. 55.

form agrees very nearly with the genus *Sphaerosira volvox*, as figured by Pritchard (edit. 1842, t. i., Figs. 48, 49). The protoplasm in which these animals were imbedded had a faint reticulated appearance, which would make it rank nearer the genus *Volvox*, and the animals could be seen waving and wriggling their tails between the meshes. Vibriones were at this time very abundant, and amongst them I observed a number of white, spherical, transparent bodies rolling through the fluid—just the kind of movement one sees in *Volvox globator*. These I believe to be *Monas umbra*, as they agree in size with that species, $\frac{1}{24000}$th of an inch in diameter.

Dr. Hughes Bennett says: "It frequently happens that, soon after some of these higher infusoria are seen, the pellicle falls to the bottom of the fluid, where it constitutes a dense precipitate, and slowly breaks down; then another scum forms on the surface, and molecules, bacteria, and vibrios are again produced."

"The varied forms produced are spoken of by Ehrenberg and other naturalists as being different species, but I think it will be found that the laws, not only of molecular, but of alternate generation and parthenogenesis, prevail among them, and one frequently passes into another."* But a little farther on he says:—"In all cases no kind of animalcule or fungus is ever seen to originate from pre-existing cells or larger bodies, but always from molecules."

The various forms as spoken of by Ehrenberg might, under certain conditions, constitute what we are pleased to call species; but we have only seen them under one condition, and that one condition has revealed these forms very distinctly, as distinctly, in fact, as many so-called species, and, so far as we know of them, they seem equally entitled to rank as such. Could their existence be prolonged, and could they be placed in more genial media, the probability is that we might see them develop into other forms. In one instance I tried this by taking what M. Pouchet has described as the perfect ovum derived from the molecular mass. I placed it in a watch-glass half-filled with water, and covered with a bell-glass; but, at the end of a fortnight, I could discover no permanent or particular development, only that the molecules had become slightly larger. But there is one thing to be observed here, the specimen might not have been placed in its proper medium, and it might not have been supplied with proper nourishment for its further development. It would therefore be wrong to say that this microcosm had reached its ultimate form. The great fact then is, that we can to a certain extent see the beginning, but we cannot at present see the end.

On the 22nd day some curious and beautiful forms revealed themselves. I observed five of them in a group, varying in size.

* 'Popular Science Review,' pp. 55, 56. 1869.

The largest measured $\frac{12}{1000}$ths of an inch across. They were tinted, of a pale-green colour. The periphery was double, like an oleaginous cell, and the molecules radiating very regularly from the centre, and it appeared to me to be formed like a concavo-convex lens, or hollow or concave on one side and convex on the other. What this really was I cannot tell, as this was the only group or specimen that I have seen, and I know of nothing like it (Fig. 14).

23rd day.—We now come to a very curious vegetable growth, springing from what appears to be only an irregular oleaginous cell; for I could not discover with the most careful investigation anything like a true vegetable cell enclosed in the oil-cell, and I have had opportunities of watching the growth of this from its first appearance, as the plant has been very frequent in the liver infusion, but I saw nothing of it in the beef (Fig. 15).

The plant first appears, as I have endeavoured to delineate it, in attached or free fusiform slightly-curved sharp-pointed fronds. They arrange themselves with their convex sides together, and they have then just the appearance of that curious Desmid *Ankistrodesmus falcatus, Corda,* and to which this seems nearly allied. On the 34th day I noted a large mass of this plant; it had then attained to the $\frac{1}{24}$th of an inch high, and the fronds of which it was composed measured about $\frac{1}{4000}$th of an inch. It had a very remarkable appearance, and reminded one somewhat of the marine plant *Sphacellaria scoparia.* I observed that the young fronds of this plant when found free in the protoplasmic film are at first quite colourless. They afterwards attain to a pale olive-green tint, and when full grown to an olive-green. I have given the name of *Chlorocyclos fasciatus* to this plant, which means a bundle of green semi-circles (Fig. 19).

From the 23rd to the 26th day I did not observe any particular change, or any further development; but on the latter day I observed a group of cells, varying in size, the largest measuring $\frac{5}{1000}$th of an inch in diameter. Each was divided into four divisions by broad dissepiments, each being provided with a double wall. They were of a delicate green colour, and reminded me very much of the cells in *Ulva crispa* (Fig. 16).

On the 34th day the beef had developed some rather different forms to those of the liver, and particularly some masses of angular cells, imbedded in a transparent film. Each angular fragment or cell had a distinct round or elliptical nucleus; some of the larger had two. These angular cells are crowded with molecules, except the nucleus, which is free. The beef appears to me to break up into these angular cells; for when a small bit was placed between slips of glass, and pressed, it broke up into little tessera, each being held together by a transparent film. (See Fig. 18.) These cells vary in size from the $\frac{2}{1000}$ths to $\frac{2}{500}$ths of an inch in diameter.

On the 38th day the vibriones had attained to a large size, and were three or four jointed, most of them having a large globose head; and I observed that the portions between each articulation were slightly curved, having a faint bluish tint. Professor Clarke, in his investigations into the structure of muscle and muscular fibre, says, although with great reluctance, he must admit the truth of what he has seen, and that is, he has observed portions of muscular fibre, or the fibrillæ, break away from the mass and swim away as vibriones. So that in fact the common muscular fibre of our and other bodies appears to be only collections of vibriones, remaining in an inactive state until liberated by the decomposition of the matter holding the vibriones together.

Now the fibrillæ of portions of muscle that I have examined from the liver of a fowl give me just the idea of vibriones being packed together transversely: they are the same in colour, the same in measurement, and the articulations are the same distance apart, and I believe it would be impossible to separate the free fibrillæ from the vibriones. I have myself seen two or three fibrillæ partly liberated from a piece of muscle moving about in the same manner as the vibriones; but when all the infusion is a mass of life, I could not positively say that what I saw was voluntary motion. At the same time, I feel convinced in my own mind that it was so.

I now come to the last group to which I have to draw attention, and these are some very remarkable vibriones. Generally speaking, these animals are simple—one to three or four articulated cylindrical creatures; but though the greater part of those in the infusion were simple, there were also amongst them a great many branched forms; some of the most curious I have sketched here (Figs. 20, 21, 22). These were observed rolling and tumbling about the fluid in a very remarkable manner. They were all tinted of a delicate blue colour, and those that I have sketched measured from $\frac{4}{1000}$ths to $\frac{6}{1000}$ths of an inch long. In the earlier stages of vibrionic life they are without the rounded heads; they seem only to take it upon themselves to wear heads at all towards the latter part of their lives. Some I observed in the beef infusion on the 52nd day had monstrous heads, belonging evidently to the *Macrocephali*. Some had two heads, one at each end; but these, I presume, would divide at the septa, and form two animals.

I will conclude with relating the experiment I prosecuted with the third vessel that I mentioned at the commencement of this paper. I began, June 8th, at two P.M., by taking a thoroughly clean glass vessel, and scalding it with boiling water. I then took out a piece of mackerel from the most fleshy part of the back towards the head; I carefully turned back the skin so that the part I took should not have been brought into contact with the air

or water in washing. The mackerel from which the piece was taken was brought directly from the oven, cooked, ready for eating. The vessel was kept carefully covered from the first, so that nothing should fall into it. Some boiling water was poured upon the piece of fish to the depth of about an inch; this was then stood on the top of the kitchen hot-plate, which, I must say, was nearly red-hot; it was left in this position for nearly an hour, when I considered it had had quite cooking enough. It was then left to cool; and it was all this time kept carefully covered with stout paper, and tied down. At six o'clock I examined some of the oleaginous cells in the thin pellicle that had formed on the surface. Some of the cells were round, others ovate or elliptical; the latter showed two very dark bands, one broad one near the middle, and the other near one end (Fig. 23). At this time I could not discover any life in the vessel; at the same time, I do not say it was not there.

At nine o'clock the next morning the whole infusion was a mass of life. Every particle that had been liberated in the cooking and heating afterwards, and they were very numerous, appeared to me to be endowed with life, that is if we are to regard animated microscopic matter endowed with voluntary motion as containing the property termed life. They appear only as animated cells, some of which were spherical, and others elliptical; the latter had each a central nucleus, like a well-defined ring, the centre of which was transparent. The spherical bodies measured from $\frac{1}{8000}$th to $\frac{1}{12000}$th of an inch in diameter, and were what I believe are called *Monas crepusculum* (Fig. 24).

The fibre of which the flesh of the mackerel is composed, when highly magnified, is seen to be transversely striated, very much like the fibrilla of muscle alluded to before. These fibrillæ break up, where these transverse striæ are observed, into minute elliptical discs or cells; and it appeared to me that directly they were set free they moved away with a very rapid motion, the same as the little monas mentioned above.

The oleaginous cells have not been less active, for some of these had by the 10th developed a vegetable growth of a very similar character to the leptomitus in the liver; but it was not the same (Fig. 25). In one cell will be observed another plant beginning to grow; it has not yet penetrated the walls of the cell (Fig. 26). I could not in this, or any others, discover anything like a vegetable cell, or sporule, and the growths always seem to me to spring from one side.

There were immense numbers of spherical oil-cells in the pellicle, and many of them had arranged themselves into little moniliform masses. These oil-cells are provided with double coats, the inner one reflecting a beautiful purple colour.

There were also great numbers of elliptical cells imbedded in

the proligerous pellicle; these had a yellowish colour, the cells being so numerous as to appear like an intricate network (Fig. 27). These appeared to me to be the same as had broken away from the fibrillæ of the flesh, the same as Fig. 6.

On the 12th the molecules, which are quite distinct from the cells before spoken of, had arranged themselves into those oviform masses described by Pouchet, and the same as I have seen in both liver and beef (Fig. 29). I also observed to-day several fine thread-like filaments of a bluish colour, having just the appearance of much-elongated vibriones (Fig. 28).

From very careful watching of this infusion it appears to me that the oleaginous cells are in themselves capable of producing these vegetable growths; for I have carefully examined this infusion, to see if I could detect anything like a sporule or vegetable cell, and have failed to do so; and yet in about forty-eight hours after the infusion was made, and had passed through such a fiery ordeal, plants were developed, and grew with great rapidity.

In conclusion, I must say that I conducted all my experiments with the greatest care, so as to prevent and protect myself against objections that I am fully aware might be raised against such experiments. There is one thing which must strike every one that has paid attention to the experiments prosecuted by the various naturalists, and that is that we all obtain very nearly the same results at all seasons of the year. Whether it be in France, Scotland, or in Devonshire, the same animals are developed, the same movements and the same formative processes go on in the molecules, whether they be of fish, flesh, or fowl. The same laws are ever and constantly at work, as well in the laboratory, in our rooms, and in the open air. And so far as all our experiments have carried us, we have seen that life resides in the most minute atom that our instruments are able to detect, and with the same force in proportion to its size as that of the most ponderous creature that inhabits the globe, and yet we cannot cry, Eureka. The great mystery of mysteries remains the same.—*Paper read before the Devonshire Association for the Advancement of Science, July.*

IV.—*On Collecting and Mounting Entomostraca.*

By J. G. Tatem.*

In this paper I propose, as shortly as possible, describing the methods employed by our late friend and member, Mr. Clayton, in collecting and preparing Entomostraca for microscopic examination, and it must be a matter of sincere regret to every one of us, that he has not survived to make the promised communication, and gratify that eager curiosity, which the neatness and brilliance of such objects, as mounted by him, so generally evoked.

It is needless to remark, that wherever water exists, containing organic matter passing into a state of decay, these active little scavengers will be met with, in greater or lesser abundance and variety; even the plash left by the summer shower, and remaining unevaporated for a few hours, may afford them. Various modes of capture must be pursued according to locality. To obtain the free-swimming oceanic species, we have obviously no other resource than the muslin tow-net, while there is practically no better means of securing the littoral species than by the collection of filamentous algæ, in which they harbour, from the rock pools, rinsing them in a basin of fresh water, and on subsidence, selecting the dead specimens. From the ponds and ditches, what may be called the bag and bottle net, is by far the most convenient and efficient implement for obtaining them. This consists of a ring, five or six inches in diameter, screwing into a staff, to which a conical bag of crinoline, or some other material readily permeable by water, is attached, a draw-string in the apex securing a short wide-mouthed bottle firmly by its neck. This net, insinuated under floating weeds or the vegetation which borders and rests upon the water, and slightly shaken, disturbs and intercepts the Entomostracans in the act of sinking to the bottom for safety. In bright sunny weather, however, when they are found in greater numbers sporting on the surface, or in the warmer water of the shallows, a long narrow-necked vial (a ten-drachm one answers sufficiently well), fastened by an india-rubber loop to the staff, dipped just below the lip, and the water allowed to flow gently in and fill it, will be found more effective. In either mode of proceeding the contents of the bottles may be run off through a Wright's collecting-bottle, until a sufficient supply is procured. I may here take the opportunity of mentioning a small improvement on Wright's bottle, effected by attaching a fan-shaped, curved plate of metal, to the entrance-tube, so directing the current of water against the muslin which covers the mouth of the outflow tube, as to prevent that accumulation of sordes upon it, which occasionally impairs its utility.

* Communication to the Reading Microscopical Society, October 19th.

It should be borne in mind, that some species of Entomostraca are strictly local, limited even to a small part of a particular pool. Daphnia mucronata, for example, will be obtainable by hundreds, from the space of a very few square yards, whilst but a solitary or perhaps not a single specimen will be found beyond the well-defined area. In such cases, local knowledge can alone avail the collector.

The Entomostraca thus secured should be picked out under the dissecting microscope, transferred to watch-glasses of FILTERED water, and allowed to remain for twenty-four hours, in order that the contents of the laden intestine may be discharged, some of which if this precaution be not taken, would, under the pressure of the covering glass, inevitably be squeezed out, and sully the mount; drawing off the water, a little spirit of wine speedily deprives them of life; and all dirt having been removed by the aid of a camel's hair pencil, they are to be placed in a few drops of diluted medium (half medium and half water) on a glass slip, protected from dust, until saturation is complete, and not until then, put up in the medium; shallow cells being mostly necessary.

After many and repeated experiments, attended with variable success, Mr. Clayton found Mr. Farrants's modification of his medium, by the omission of the arsenic, and the reduction of the glycerine to a minimum, on account of the known effects of that fluid in slowly dissolving the carbonate of lime of shell, gave the best results, in the greatest amount of transparency and permanence of which such subjects are susceptible. The receipt is as follows:—Gum arabic (picked), 1 oz.; distilled water, 1 oz.; glycerine, $\frac{1}{2}$ oz. The gum to be dissolved in the water, the glycerine added, and the whole filtered through white blotting-paper previously moistened with distilled water.

In giving this brief account of the late Mr. Clayton's practice, I can only express the hope, that some of our members, through the information now afforded, may be induced to emulate that manipulative skill which made his preparations unrivalled as yet in excellence, and that through them, his endeavours to preserve the Entomostraca as permanent objects for the microscope may be carried to a still higher degree of perfection.

PROGRESS OF MICROSCOPICAL SCIENCE.

The Movement of the Protoplasm in the Cells of Anacharis alsinastrum.—Under this title a very valuable paper of 26 pp. appears, by Prof. J. B. Schnetzler in the *Archives des Sciences* for September 15. The author goes into the history of the observations made upon the plant, and then details a number of experiments, made with a view to determine the different effects produced on the movement of the protoplasm, by heat, light, electricity, and chemical action. In his opinion light and heat have most to do with the motion. The most refrangible waves of light have the greatest influence, but heat seems to be the all-powerful agency. Electricity has its own action, but not an extensive one, while gravity seems to have little or nothing to do with it. The author thinks that we have here a marked example of the conversion of heat and light into mechanical motion.

The Structure of Nerve-tissue generally.—A useful review of recent labours on the histology of the nervous system will be found also in the above journal. It is possibly from the pen of M. Claparède.

Tænia cucumerina.—M. N. Melnikow, of Kasan, contributes an account of this cestoid to the *Archiv für Naturgeschichte* (Heft 1, 1869). He gives three figures of the worm, and refers to the labours of Van Beneden, Leuckart, and Cobbold.

The Structure of the Mucous Villi.—Herr Dr. Th. Eimer, of Würzburg, has contributed a lengthy physiological paper on the subject of the absorption of fatty matter by the villi to Virchow's *Archiv* (Band 48, Heft 1). In this he describes the structure of these mucous processes, both in fresh specimens and in specimens prepared with osmic acid, chromic acid, and other substances. The sketches of the structure which he has given are most elaborate, and his researches tend to show that fats are absorbed through the connective-tissue system of canals lying in the mucous membrane.

The Arrangement of the Outer Nervous Layer of the Cerebrum.—Dr. Rudolph Arndt's researches in this structure reveal a complexity of construction not dreamed of a few years since. It would be impossible to attempt an abstract of his results, which occupy nearly a sheet of the journal in which they are published.—Vide *Archiv für Mikroskopische Anatomie*, 5 Band, 3 Heft. Various other papers of importance on the structure of the nervous system appear in this journal.

The Anatomy and Development of the Reproductive Apparatus of Lymneus.—This is a very interesting and painstaking account of the construction and development of the generative system of an air-breathing mollusk; and is illustrated by some very good sketches. It does not, however, decide the question as to the well-known hermaphrodite gland.—See Siebold and Kölliker's *Zeitschrifti*, 19 Band, 3 Heft, issued September 6.

The Development of Insects.—In the preceding valuable journal will also be found an excellent paper, by Herr Ganin, on the development-history of Insecta. The author deals principally with *Platygaster*, *Polynema*, *Teleas*, and *Ophioneurus*, and gives about seventy exquisite illustrations in three large folding plates.

Tactile Corpuscles in the Parroquet's Beak.—Dr. E. Gougon has a curious paper on this subject in the *Journal de l'Anatomie* for October. He gives a section of the beak, showing what he regards as groups of Pacinian corpuscles, and he gives some figures of these bodies separately examined, which seem to bear out his assertion of the existence of these corpuscles. The author admits that there are difficulties in the way of accepting this view, but he thinks that the fact that the parroquet uses its beak as a tactile organ is sufficient to obviate them.

Our Knowledge of the Retina.—Professor Krause, of Göttingen, gives a sort of critique of the work done on the retina from the year 1856 to 1868, in the above number of the *Journal de l'Anatomie.* It will be found a valuable retrospect for those engaged in the histology of the eye. It was begun in the previous number, and will be continued in the next. It analyzes the views of the author, of Schultze, Hulke, Zenker, Valentin, Babuchin, Steinlin, Müller, Henle, and others.

The Latex-fluid of the Mulberry. — Great difference of opinion exists as to the nature and uses of this curious fluid, and of the system of vessels by which it is conveyed. In a paper published in the *Annales des Sciences* [t. x.], M. E. Faivre discusses the opinions of Schultze, Trécul, Naudin, Von Mohl, and others, and concludes by regarding the latex as a nutritive fluid, an elaborated sap, conveying materials for growth. It may contain other matters also, but it is not on that account to be regarded as excrementitious.

A Sea-deposit destitute of Foraminifera.—Mr. Charles Bailey, who has been examining the foraminifera sands of Connemara, recently drew attention to the fact, that while examining some sands in Dog's Bay, Connemara, he found a deposit in a small creek on the southern shore of the bay, which, from its being sheltered by rocky sides, he felt sure would yield foraminifera. On a minute examination, however, of the materials composing its beach, there was a singular absence of foraminifera, scarcely a single example of these creatures being discoverable. The beach was uniform in character from low-water to high-water mark, and was for the most part made up of fragments of molluscous shells mixed with coarse grains of sand. This deposit is the more remarkable from the contrast it presents to the rest of the beaches in the neighbourhood, those of Dog's Bay and Gorteen Bay being made up of considerably finer materials and abounding in foraminifera; further, the most perfect specimens of foraminifera are found round the next headland, not many yards from the creek in question.—See 'Proceedings of Lit. and Phil. Soc. of Manchester,' issued in October.

The Microscopical Examination of the Dog-woods.—In 'The Student' for October, Mr. J. R. Jackson, in a paper on the dog-woods used for

making gunpowder, has given an illustration of the practical use of the microscope in diagnosing the different forms of stems. He has given the characters of the sections (transverse) of different species, and has delineated them in a handsome plate.

The Embryogeny of Crustacea.—M. Edouard Van Beneden continues his inquiries on this interesting subject. In his last memoir, which he has reprinted from *Bulletin de l'Académie Royale des Sciences* of Belgium, No. 8, 1869, he deals with the development of *Mysis*, selecting *M. ferruginea* as a type. A 4to plate contains several figures illustrating the different phases of the ovum, from the time when the embryonical development has hardly begun, up to the date when it has undergone all the development that takes place within the egg. He thus sums up his conclusions:—(1) The blastoderm is formed in the course of a partial segmentation of the vitellus. (2) The cellular zone, which results from the multiplication by division of the cicatricule, extends itself over the whole surface of the egg, to form a closed blastodermic vesicle, before any trace of organs is seen. (3) The division of the embryo into a cephalic and a caudal lobe results from the division into two laminæ of a primordial cellular fold, which may be compared to the cellular column [Keimhügel] of Hemiptera, Orthoptera, and Lepidoptera. The identity of formation of these organs, which have evidently the same morphologic value, and the perfect analogy between the phenomena which subsequently take place in the cephalic lobe in the crustacea on the one hand and the insects on the other, are in my opinion facts which enable us to determine with ease and certainty what are the homologous organs in these two groups of Arthropoda. (4) The caudal appendage of *Mysis* is folded under the abdomen as in all Decapods. (5) The caudal lobe commences to be formed before it is possible to recognize the least trace of antennary appendages; these appear at the same time as the mandibles in the form of simple cellular papillæ. (6) The Nauplian cuticle is formed at once over all the surface of the embryo; it is the first embryonic cuticle. *Mysis* does not undergo a blastodermic moult. (7) The tail, which is bifid in some species (*M. vulgaris* and *M. chameleo*), is simple, and terminates in a cul-de-sac in other species (*M. ferruginea*).

Regeneration of the Spinal Cord.—In a recent series of researches on frogs, MM. Masius and Vanlair have arrived at certain conclusions, which are thus expressed by M. Th. Schwann in his report to the Belgian Academy. (1) The spinal cord in the frog repairs the destroyed tissue by means of a new medullary tissue. (2) The return of the functions which had been previously suspended coincides with this repair; and (3) In reproducing the structure, cells precede fibres in course of development.—*Bulletin de l'Académie Royale de Belgique*, No. 7. 1869.

The Development of the Crystalline Lens.—M. Woinow, of Moscow, recently presented a memoir on this subject to the Vienna Academy of Science. It has not yet been published in full.—*L'Institut*, Oct. 13.

The Structure of the Cerebellum.—Herr Obersteiner publishes a

paper on this subject. He says that we may distinguish in the cerebellum of the infant five layers, one of the character of connective tissue, and the others of nervous substance. The cells of Purkinje exist at that period in the fourth layer. In the fully-formed cerebellum we distinguish the basal layer, the exclusively grey layer, the universal cellular layer, and the rusty-coloured layer. Purkinje's cells present some differences, according as they are situated at the summit or bottom of a convolution, and notwithstanding their innumerable ramifications of extreme fineness, all the processes of the same cell extend in a plane vertical to the longitudinal direction of the *bourrelet.* Both cells and their processes bear characteristic striæ.—*L'Institut,* September 22.

The Fossil Bryozoa of Bessarabia formed the subject of a paper presented to the Academy of Science of Vienna, at the meeting held in June, by Herr Reuss. Some of the Oolitic deposits of a porous character, and composed in great part of shells, enclose the remains of Bryozoa in large quantity. The author found four species, two of which—*Hemieschara variabilis* and *Diastopòra corrugata*—were remarkable by the extreme variety of their forms.

Tuberculous Deposit in the Tissues.—The eleventh report of the Medical Officer to the Privy Council contains a most admirable paper (of great length) by Dr. Burdon-Sanderson on his experiments in inoculating tuberculous matter. It is illustrated by a multitude of beautifully-tinted lithographs, showing specimens of various tissues containing the tubercular material as an interstitial deposit. It is most creditable to Mr. Simon that such good work should be done in his department.

Nobert's Lines Photographed.—The last number (September) of Silliman's 'American Journal' contains a brief paper on the above subject by Col. Woodward. As the facts have, however, been already brought under the notice of the Royal Microscopical Society at its last meeting, in a paper which shall appear in our next issue, it is unnecessary to refer further to the matter.

Rain-water under the Microscope.—'Scientific Opinion' (October 13) has extracted with illustrations some remarks of Dr. Angus Smith, F.R.S., on the microscopical examination of rain deposits. The subject may be of interest to certain of our readers.

Cells within Cells.—In the notes to his French edition of the 'Fertilization of Orchids,' which Mr. Darwin has recently prepared, he gives the following account of his attempts to enumerate the pollen-grains of one flower:—"I have endeavoured," he says, "to estimate the number of pollen-grains produced by a single flower of *Orchis mascula.* There are two pollen-masses; in one of these I counted 153 packets of pollen; each packet contains, as far as I could count, by carefully breaking it up under the microscope, nearly 100 compound grains; and each compound grain is formed of four grains. By multiplying these figures together, the product for a single flower is about 120,000 pollen-grains. Now we have seen that in the allied *O. maculata* a single capsule produced about 6200 seeds; so that there

are nearly twenty pollen-grains for each ovule or seed. As a single flower of a *Maxilaria* produced 1,756,000 seeds, it would produce, according to the above ratio, nearly 34,000,000 pollen-grains, each of which, no doubt, includes the elements for the reproduction of every single character in the mature plant!"

The Microzymæ of the Blood.—MM. Béchamp and Estor have been experimenting on the coagulation of blood and studying the phenomena with the microscope, and they arrive at some very startling results. The *Microzyma* is according to them a minute vegetable form, so small that numbers of them are arranged together in one Bacterium. From the results of their observation of the blood, they conclude that the fibrine is nothing more than a sort of membrane (like the vinegar plant, in fact) formed of these microzymæ of the blood accumulated together.—Vide *Comptes Rendus*, September 20.

Microscopic Investigation of Milk and Blood of Animals with Foot and Mouth Disease.—In the 'Lancet' of October 23rd, Professor Brown has given a very elaborate account of his inquiries on this subject. When the disease is fully developed, about the third day from the first appearance of vesicles, the milk invariably contains morbid products of a very pronounced character, which were shown in one of the figures. This specimen was taken from a cow which had been suffering from the disease for ten days. The fluid, after standing for some time, separated into two parts—a curdy deposit and an amber-coloured whey. The same elements were found in both constituents—*viz.* large granular masses of a brownish-yellow colour, numerous pus-like bodies, bacteria, vibriones, moving spherical bodies, and a few milk-corpuscles. It is particularly worthy of remark that these morbid elements were found in specimens of milk which in their physical character presented no appreciable peculiarity. In some specimens which were viewed with the micrometer eye-piece the milk-corpuscles varied in size from $\frac{1}{2000}$th to $\frac{1}{10000}$th of an inch in diameter, and the granular masses from $\frac{1}{500}$th to $\frac{1}{1000}$th of an inch. Milk from animals affected with cattle plague and also with pleuro-pneumonia was always found to contain an abundant quantity of the granular masses and pus-like bodies; and in cases of cattle plague similar elements were distinguished in the curdy exudation which existed in the mucous membrane of the mouth, pharynx, trachea, and bronchial tubes. Examples of milk taken from animals in different stages of foot and mouth disease afforded very interesting results. At the commencement the specific gravity fell to 1024–5, and continued to range between the two numbers until the animal was convalescent, when it rose to 1026–7, which standard was not exceeded for two months after recovery. The granular masses and pus-corpuscles decreased in number as the affection subsided; but in all the specimens examined after the animals had recovered, they were found scattered here and there among the milk-corpuscles; and even in specimens which were examined a month after recovery, they were detected. The granular masses were not found in milk from the same animals two months after recovery, but even in these specimens a few pus-like corpuscles were present.

Two examples of milk taken from cows on the fourth day of the disease were found to be highly charged with granular masses; the milk, however, was remarkably rich in quality, having a specific gravity of 1034, and yielding a large proportion of cream. Diminution of the quantity of milk is invariably observed during the progress of any febrile disease; and in foot and mouth complaint the loss is sometimes considerable. Cows, when suffering from the worst form of disease, lose nearly all their milk; but when the attack is mild in character, the decrease will not be more than one-third of the usual yield. The average loss in a large dairy while the disease is going through the sheds will vary from one-third to two-thirds, according to the number of severe cases. As all the milk obtained is mixed, the worst milk will be to some extent modified by the addition of that which is less highly charged with morbid elements, and the whole is further diluted by the addition of water, which, judging from some specimens obtained from an establishment where the disease was known to exist among the cows, is sometimes added to the extent of 40 per cent. Boiling the milk has been recommended for the purpose of preventing or lessening its injurious action; but as a matter of fact it may be stated that boiling does not alter the appearance of the morbid elements, nor does it arrest the movements of bacteria in the fluid. No changes of a specific kind have been observed in the blood of animals affected with foot and mouth disease. The blood-discs, when examined immediately after the blood is taken, will be seen to be covered with projecting peculiar points; but after a short time many of them resume the normal circular form. The white corpuscles are in excess, and there are also present minute circular bodies, which move actively; but all these phenomena may be observed in the blood of animals suffering from other diseases. Numerous examinations of the flesh of cattle which have been destroyed while suffering from foot and mouth disease have been made at various times; but no important morbid changes have been detected. In many specimens the peculiar worm-like bodies, which were found so abundantly in the muscles of animals dead of cattle plague, have been seen; but seldom in large numbers. The meat, however, presented no indications of disease, and, considering that an enormous quantity of such meat has been consumed during the last four months, it can scarcely be imagined that the flesh of animals affected with foot and mouth complaint possesses any deleterious qualities.

The Ratio-micro-polariscope.—In a paper read at a late meeting of the Quekett Club, Mr. J. J. Field gave the following account of this instrument, which he has recently constructed, and of its uses:—No microscopist need look very far through his collection before meeting with certain structures that altogether refuse to be evidenced without polarization; but in such cases even polarized light is of little avail, unless certain exact conditions, or at all events a very near approximation to such exact conditions, of the polarized beam in relation to those structures can be commanded. Indeed, I have repeatedly observed that when polarized light is employed in a haphazard manner, it may indeed paint the object with gorgeous hues; but

instead of developing, it too often optically obliterates detail. It is the aim of the instrument—the construction of which I shall now describe—to displace this haphazard mode of operating, and enable microscopists to mete out to each particular structure its own special needs and requirements. This is what I claim for it, and I believe that in the hands of those who will take the pains to become practically acquainted with its capacities, and have patience to vary its combinations until the correct ones be found, it will prove a valuable aid, not only in study, but also in original research. The instrument consists of a frame carrying a Nicol's prism and three plates of selenite. The prism is arranged in a rotating collar, and the selenite plates above the prism are fitted into movable cells, toothed around their circumference. At one side of the apparatus there is fixed a metal pillar, upon which are arranged three toothed wheels, which only move in unison; and the toothed selenite cells are so arranged as to size, that they gear into these pillar wheels, and take motion from them; whilst, at the same time, the relation between the wheels is such, that during one revolution of the first selenite, the second accomplishes two, and the third three. As a matter of convenience a fourth wheel is added, cut with the oblique teeth needed to gear into a four-threaded driving-screw; this latter being the means of giving motion to the whole. Over the selenites is placed a condenser, constructed on the principle of a Kellner's eye-piece, the field lens of which receives the whole of the polarized beam, and converges it upon an achromatic combination, so that no diaphragm being needed, the entire beam passes to the object. Lastly, there is an arrangement by which the selenite cells can be instantly ungeared, and turned singly with the finger, so as to have their depolarizing axes set in any relative position that may be desired at starting; and in order to make every position certain, and referrible for reproduction at any after-time, each cell is graduated, and reads from an index on its own bearing. The circumference of the prism collar is also graduated through a certain range, and there is a small projecting stud in the upper part of the apparatus, intended to fit into a corresponding recess to be made in the sub-stage of the microscope, so as to ensure the apparatus occupying on every occasion the same exact position. Thus the whole optical arrangement, when placed for use in the sub-stage, may always be set at zero; and as a consequence, when once the exact adjustments for developing any particular structures are found, they can be recorded, and instantly reproduced when needed.

Now, supposing the selenite plates to be so locked in the driving-wheels that their positive axes all point to zero, it is clear that, on turning the driving-screw, so soon as the first selenite begins to move, the second will be gradually parting company with it; and the third (as to axial relation) will be in advance of both; and since the rotation of each selenite plate corresponds optically (within the limits of that one plate) to its gradual reduction in thickness,* and

* It is not intended to be conveyed that the rotation of any single selenite plate corresponds optically to such a reduction in thickness as to confer upon it the chromatic range of the spectrum; but only to such a reduction as is competent

all three selenites, starting from zero, can only resume that position after three entire revolutions, during every portion of which they are all occupying different axial relations to one another and to the object, it is manifest that the optical effect must be the same as though a great number of different thicknesses of selenite had been tried in succession. Thus, in examining any object by polarized light, it is only necessary to make three entire turns of the driving-wheels; and then, if the exact selenite supplement needed for developing the structure be within the compass of the zero setting, *some position* must be arrived at in which the details sought may be made to appear with the greatest possible distinctness. Should not this be the case, the selenite cells are to be ungeared, the plates re-set, with their axes more or less *out of coincidence*, and the former operation repeated, and so on. It will thus be seen that the number of variations this instrument is capable of producing—variations that may be so conducted as to create a gradually increasing or diminishing effect *in the direction that appears to be needed*, and which variations, starting as they do from known data and proceeding in known ratio, can always be reproduced at will, are almost endless. The ratio movement, by spreading out the depolarizing axes of the selenites in a predetermined order (something after the fashion of the opening of a fan), enables the observer *rapidly* to arrive at an APPROXIMATION to the most perfect optical conditions for viewing any particular structure; *and then*, in order to arrive at *absolute perfection* in the development of the details, nothing is needed but a little time and patience, to change the setting, tooth by tooth (in the direction indicated by the previous adjustments), until further change becomes detrimental.

By a very simple notation, fine positions can be instantly recorded and afterwards read at a glance; and although many trials are generally needed to arrive at the *finest effects*, still, when any adjustment giving *superlative results* with any special object is found, such adjust-

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to diminish the intensity of its effect from the maximum, gradually onwards to the minimum, until one of the neutral axes is reached. But in this instrument there are three selenites, of such substance that *in a certain set position*, in which each plate is individually active in the production of colour, white light results, in consequence of the chromatic interferences mutually neutralizing one another. It is therefore clear that the least motion of the driving-screw will, in the most gradual and micrometrical manner, *upset this balance of colour*, by diminishing the power of A more than B, and of B more than C, and by continuing the motion, this change in the proportion of the three colours composing the depolarized beam will proceed in the same direction, and in the same ratio, until one of the neutral axes is reached, in which position A becomes at once inoperative. On again driving the selenites, A begins to increase in intensity whilst B is diminishing; and soon another neutral axis being reached, B, in its turn, becomes inoperative, and then having passed the neutral position, proceeds onwards, with gradually augmenting power, to reinforce A, and so on. It will be seen therefore that the rotation of the selenites, as here effected, corresponds *in the fullest sense* to gradual reduction in thickness; and I may compare the depolarizing effect so produced to that of passing beneath the object a wedge of selenite, of micrometrically small angle and of infinite length; and the chromatic results to those obtained by an artist, who, having the primary colours, A, B, and C on his palette, has the power of combining them in all proportions, and skilfully mingles them according to his wants.

ment will prove by no means to be limited to the single object viewed, but also to embrace *somewhere within the limits of a half rotation of the lower prism* (the selenites themselves now remaining stationary) the finest optical development of many other slides containing tissues of the same or closely allied character. For example, I found a magnificent setting for exhibiting the cuticle of the Equisetum; and I have no vegetable cuticle in my possession that does not come out *superbly* under the same selenite adjustment, but with a different position of the polarizer. So in relation to deep-coloured entomological objects difficult to polarize, and many others, they class themselves under certain optical heads *as to the settings*, only needing a changed position of the polarizer; and thus a great amount of time and labour is saved, for the *prism* can be set to its recorded reading *instantly*, whilst the instrument remains *in situ*—in fact, without any disturbance of the general arrangements at all. Lastly, by means of this polariscope the elementary colours can be mingled in any order or proportion that may be desired; so that *any coloured field whatever, of absolute uniformity throughout*, from the dirtiest brown to the deepest and purest azure blue (even by lamp-light), may be produced instantly by making a known setting. In conclusion, I wish to point out that this is essentially an instrument of precision, and therefore demands skill and patience on the part of the operator to make it do its work; but when employed with the ability and tact characterizing all skilled microscopists, it is competent to yield results of surpassing delicacy and beauty.

This demand upon the operator's skill and patience, however, is only that made by every instrument of precision (witness wide-angled objectives); for the greater the range and powers of any instrument, the more care and thought must necessarily be employed in its use.

NOTES AND MEMORANDA.

The Montreal Microscopic Club.—This club, which was established last year, has already proved itself a success. In plan it is something like that excellent working body the *Dublin Microscopical Club*. The club appoints a secretary, who arranges for the meetings, and suggests a special subject for illustration at each. The host for the evening is the President of the club; minutes are recorded and read, visitors introduced, miscellaneous business discussed, and microscopic investigation proceeded with. At 10.30 P.M. the President announces the adjournment, the microscopes are returned to their cases, and a parting cup of coffee closes the *séance*. During the intervals of meeting the Monthly and Quarterly Microscopic Journals circulate amongst the members, and afford material for discussion and illustration.

A Translation of Stricker's Histology.—It is said that the New Sydenham Society has selected for translation Herr Stricker's 'Handbuch der Lehre von den Geweben.'

Photographing Diatoms.—The 'British Journal of Photography,' in replying to a correspondent, suggests that he should avoid difficult subjects; at first it would be much better to try such an object as *Pleurosigma littorale*, which contains 24,000 lines to the inch, than the *P. macrum*, which contains 85,000, and would require an objective of $\frac{1}{12}$th of an inch to show the markings. The former is within the range of a good $\frac{1}{4}$-inch power, the latter could not be seen by it.

Polarizing Crystals from Logwood.—At the concluding sessional meeting of the Literary and Philosophical Society of Manchester, Mr. Dancer stated that he had received from Mr. Richard Dale, Cornbrook, some Hæmatoxylin—the source of the colouring properties of logwood. From the appearance of the crystals Mr. Dale expected they would form a polarizing object, and Mr. Dancer found that opinion to be correct. Mounted slides of the crystals from an alcoholic solution were exhibited to the meeting by polarized light; they are quite equal to Salicin in intensity of colour, and do not require the aid of a selenite stage. They form a welcome addition to the list of polarizing objects.

Milk of diseased Cows under the Microscope.—In the 'Lancet' of October 23rd, Professor Brown has given an account of his observations on the milk of cows suffering from the "foot and mouth disease." He has given numerous illustrations of specimens seen under high powers, and showing the presence of Bacteria and allied vegetable forms in abundance. The details will be found in our summary of "Progress."

The Microscope attacked and defended in Paris.—A great battle has been taking place in the French journals between two well-known *savants*. M. Nélaton, surgeon and senator, contended that the microscope is valueless in medicine, and that it often leads to mistaken diagnosis. But his assertions have not passed unchallenged, for M. Verneuil has given him a pointed reply in the columns of the 'Gazette Hebdomadaire.' After having stated what great results the microscope has afforded in the hands of such men as Robin, Broca, Lebert, Davaine, Virchow, Kölliker, and others, and after having mentioned that it had now become the indispensable complement of anatomical research in the dead-room, throwing a brilliant light on the origin, the evolution, and the transformation of those innumerable lesions which destroy man, M. Verneuil asked M. Nélaton whether he believes that *all* surgical science may be acquired in the ward of an hospital. If not, and if, on the contrary, he (M. Nélaton) admits the assistance of the accessory sciences, if he makes use of chemical agents and of physical instruments, if he practises vivisections, if he utilizes statistics, if he consults J. L. Petit, Scarpa, Langen, and Syme, why should he disdain the microscope? "For if it is good to diagnosticate stone by the aid of a sound, polypi with the laryngoscope, an amaurosis with the ophthalmoscope, paralysis by means of an electric machine, diabetes with potash, why reject the lens for recognizing leucocythæmia or spermatorrhœa?"

PROCEEDINGS OF SOCIETIES.*

Royal Microscopical Society.

King's College, *October* 13, 1869.

The Rev. J. B. Reade, F.R.S., President, in the chair.

The minutes of the last meeting (June 9th) were read and confirmed.

A list of donations was read, and the thanks of the meeting presented to the respective donors; a special vote being accorded to Mr. Ross, who, as the President announced, had given to the Society new immersion front lenses for the $\frac{1}{8}$th and $\frac{1}{12}$th object-glasses which he had already presented to the Society.

The President said that it had been intended that a paper by Dr. Pigott, of Halifax and London, "On High-power Definition, with Illustrative Examples," should have been read; but it would be deferred until the next meeting, when he hoped Dr. Pigott would be in London, and able to read his communication personally. The President explained that the paper contained an account of an examination of the Podura scale, which gave results quite different from those which were usually obtained, the whole surface of the scale being resolved by Dr. Pigott into minute beads; and the President handed round a drawing made by Dr. Pigott in which the "note of exclamation" marking generally seen by observers appeared as a number of bead-like bodies. The President, while reserving his own doubts as to the accuracy of Dr. Pigott's views, hoped that before the next meeting the Fellows would examine the object for themselves, and come prepared to discuss it. The President also announced that Mr. McIntyre would read at the meeting in November, a paper on a related subject, *viz.* "The Scales of Certain Insects of the Order Thysanura."

Mr. Slack observed that it might assist Fellows who wished to take part in the discussion that would be raised by Dr. Pigott's paper if they examined a good test Podura scale with a high power and unilateral light obtained by Reade's prism, or by a single radial slot-stop in an achromatic condenser. With Beck's $\frac{1}{20}$th he could easily show a dotted structure; but several appearances obtained by varying the incidence of the light, and by infinitesimal changes of focus, seemed equally entitled to consideration, and were very difficult to interpret.

Mr. Hogg exhibited a phial containing a quantity of *dichroic* fluid which had been found by Mr. Allbon in a ditch not far from town.† The fluid obtained by Mr. Sheppard, of Canterbury, who first discovered and described it, contained a great deal of animal life, while that exhibited by Mr. Hogg was almost entirely composed of a con-

* Secretaries of Societies will greatly oblige us by writing out their reports legibly—especially the technical terms—and by "underlining" words, such as specific names, which must be printed in italics. They will thus ensure accuracy and enhance the value of their proceedings.—Ed. M. M. J.

† We learn from Mr. Reeves, Assistant-Sec. R. M. S., that Mr. Allbon's fluid came from a ditch between Mortlake and Kew, and contained Batrachospermum atrum in a decomposed state.

fervoid growth, the sides of which were covered with cells filled with pseudo-naviculæ. When examined by transmitted light the fluid gave a delicate bluish pink colour, and by reflected light a reddish hue. Under the micro-spectroscope, its spectrum is just that described by Mr. Browning in vol. vii., 1867, of the Society's 'Transactions.' A few pieces of camphor serve to preserve the fluid; and although the specimen exhibited had been corked up for several months, the colour is nearly as good as when it was fresh gathered, and the spectrum reaction quite perfect.

The President then requested Mr. Carruthers to read a paper on the "Plants of the Coal-measures."

Mr. Slack wished to call the attention of Fellows conversant with crystallography to the curious instance mentioned by Mr. Carruthers, in which, after the charring of the vegetable structure, although the particles of carbon preserved the exact form of the vegetable cells, they had opposed no obstacle to the crystallization of the carbonate of lime, which had gone on through their interstices as though no obstacles had intervened.

Mr. C. Brooke stated that structure is much interfered with by foreign matter—the sandstone of Fontainebleau, for instance, assumes the form of rhombohedral crystals of calcite. The stone does not contain more than 5 to 7 per cent. of carbonate of lime; but the 95 per cent. of silex seems to be dragged into form by the 5 per cent. of carbonate of lime which controlled the character of the crystallization.

Dr. Murie alluded to the preservation of the form of straw after carbonization in a furnace.

Mr. Browning suggested, as an important line of research, that certain organic fluids should be mixed with solutions of crystallizable substances, in order that it might be seen in what cases the organic matter would be enclosed in the crystals formed by evaporation.

Dr. Lawson hoped that the Fellows would employ a little of the time hitherto devoted to the study of Diatoms, &c., to the interesting questions brought forward by Mr. Carruthers. With reference to the remarkable combination of types mentioned by Mr. Carruthers, he would ask whether he considered these cases as corroborative of the Darwinian doctrines?

The President said it was satisfactory to note the important service rendered by the microscope in Mr. Carruthers' investigations. He thought Dr. Murie's remarks not exactly parallel to the instances adduced by Mr. Carruthers. Dr. Murie showed that the process of carbonization did not interfere with the form of the original structure of the solid material of plants; but this was not the point taken up by Mr. Carruthers, who showed that the process of crystallization was not interfered with by the presence of foreign matter. He (the President) had tried several experiments with cereal plants, which he burnt in a platinum spoon, and found that by taking a small portion of the siliceous residue, which he could just see with the naked eye, and placing it under a $\frac{1}{8}$th glass, that the beautiful conformation of the solid structure of the plant was distinctly seen. The President then proposed a vote of thanks to Mr. Carruthers for his interesting address.

Mr. Carruthers in expressing his acknowledgments for the manner

in which his address had been listened to, declined entering upon the Darwinian controversy.

Mr. Hogg then read a paper, by Brevet Lieut.-Colonel Woodward, Assistant Surgeon of the United States army, on "Immersion Objectives and Nobert's Test-plate," which will appear in the next number of the Journal.

Mr. Hogg said he thought that the paper prints of Nobert's test-lines were better than the glass positives received with the paper and exhibited to the meeting; that in his opinion the photographs taken with Powell and Lealand's $\frac{1}{25}$th last year by Dr. Woodward were far more perfect, the lines being more sharply defined. The wavy indistinctness which Dr. Woodward in his former paper said represented spurious lines could be seen in all the bands; on close inspection of the two photographic paper prints, which were said to show spurious lines in the 12th, 13th, 14th, 17th, and 18th, it was difficult to say whether there is any difference between them and that said to resolve the 18th and 19th bands into true lines. He had observed a fine series of lines barely separated from the rest by a dark broader line in most of the bands, which were doubtless due to diffraction; but another set of very fine lines on one side of the 19th band looked more like true lines than those believed to be so. These lines also increase the difficulty of counting accurately, and consequently he had not been able to satisfy himself in a single count. He (Mr. Hogg) would like to ask Messrs. Powell and Lealand whether the immersion lens used by Dr. Woodward can be used either as a wet or dry objective; and what is the increase of the magnifying power of their $\frac{1}{16}$th when converted into an immersion lens? In Mr. Hogg's opinion immersion objectives were a great gain to microscopists.

Mr. Browning said that diffraction spectra would almost certainly be produced by Nobert's lines acting as a grating. The lines seen on each side of the bands had probably this origin. If spectra overlapped each other, a certain number of the lines would probably be lost. He did not think the limits beyond which no lines could be resolved could be determined theoretically. It must be decided by experiment, and the investigation had to be carried on under great difficulties. He suggested *thallium* as the best source of a pure monochromatic light.

Mr. Brooke thought that the bands brought out on the photographs referred to by Mr. Hogg, were much more clearly marked than on the glass slides, for on both sides of the latter spectral lines would be observed. Again, on one side of the plate six lines would appear in a band, on the other side fourteen could be seen. These appearances were probably due to the oblique direction of the light.

Mr. Lobb doubted whether the lines on Nobert's test-plate could be clearly defined beyond the 16th band by any glass whatever; but Messrs. Powell and Lealand had constructed a test-object ruled at the rate of 100 lines to the $\frac{1}{1000}$th of an inch. These were clearly defined by their $\frac{1}{12}$th and $\frac{1}{16}$th immersion lenses. The podura scales were beautifully defined by the same objectives, and so were the lines on the *acus*.

Mr. Lealand said that the $\frac{1}{16}$th constructed by his firm could be used either as a wet or dry objective. The magnifying power of the

dry objective was about 800, and as a wet objective the power was increased by about $\frac{1}{4}$, making the magnifying power about 1000.

Mr. Mayall defended the paper which he had written on the subject of Nobert's test-lines, having taken Dr. Woodward's paper as it was printed. He thought that Dr. Woodward, when he wrote his former paper, had not carefully studied the immersion system. In his previous paper, he (Dr. Woodward) spoke of not finding the $\frac{1}{11}$th of Hartnack go as far as the $\frac{1}{25}$th dry lens of Powell and Lealand. In the present paper he said that the $\frac{1}{11}$th of Hartnack did more than Powell and Lealand's $\frac{1}{25}$th or $\frac{1}{50}$th; that is, he could define as far as the 15th band. He (Mr. Mayall) had said that he could not count the lines beyond the 12th band, and he still maintained that in a photograph no band beyond the 12th could be counted; the uncertain number of spectral lines rendered this very difficult.

A vote of thanks was then passed to Dr. Woodward for his communication.

The meeting was then adjourned until the 10th of November.

Donations to the Library and Cabinet from June to Oct., 1869:—

	From
Land and Water. Weekly	*Editor.*
Scientific Opinion. Weekly	*Editor.*
Society of Arts Journal. Weekly	*Society.*
The Student. 3 Parts.	*Publisher.*
Popular Science Review, Nos. 32–3	*Publisher.*
Transactions of Linnean Society, Part 3	*Society.*
Smithsonian Report for 1867	*Institution.*
Natural History Transactions of Northumberland and Durham, Vol. III., Part 1	*Society.*
Journal of Quekett Club. 2 Parts	*Club.*
'Reade's Prism.' By S. Highley	*Author.*
Canadian Journal.	
Quarterly Journal of Geological Society	*Society.*
Journal of Linnean Society. 3 Parts, and Vol. XII.	*Society.*
Retia Mirabilia Circumvertibralia. By Dr. J. Schöbl	*Author.*
Report on Excisions of the Head of the Femur for Gunshot Injury. By Lieut.-Col. G. A. Otis, U. S. Army	*Surgeon. Gen. U. S.*
Sulla Produzione di Alcuni Organismi Inferiori esperienze. Professori G. B. Crivelli and L. Maggi	*Authors.*
Intorno Alle Cellule del Fermento. Professori G. B. Crivelli and L. Maggi	*Authors.*
Intorno al Genere Æolosoma del Professor D. L. Maggi ..	*Author.*
A Translation and Abridgment of all the Papers relating to Natural Philosophy read before the Royal Academy of Sciences at Paris, from 1699 to 1720. By John Martin, F.R.S., and Ephraim Chambers, F.R.S.	*Dr. Millar.*
Description Raisonnée des Organes des Plantes. Par M. A. P. De Candolle. 2 Vols.	*Dr. Millar.*
Photograph of Microscopic Life. By H. Davis, Esq., from a drawing by H. Richter, Esq.	*H. Davis, Esq.*
One dozen Slides of Test-objects	*W. Wright, Esq.*
Half-a-dozen Slides of Max Schultze's Siliceous Vesicles, illustrating Diatom Structure	*Thos. Hennah, Esq.*
One dozen Injected Slides, from different parts of Dr. Thudichum's Trichinous Rabbit	*Mr. Thos. Norman.*
Immersion Fronts to Mr. Ross's $\frac{1}{8}$th and $\frac{1}{12}$th Objectives ..	*Mr. Thos. Ross.*

WALTER W. REEVES,
Assist.-Secretary.

Quekett Microscopical Club.*

At the ordinary meeting of the club, held at University College, September 24th, P. Le Neve Foster, Esq., M.A., President, in the chair, five new members were elected, and five gentlemen were proposed for membership. A number of donations to the club were also announced, and the thanks of the meeting returned to the donors. The Secretary read a paper by the late Dr. J. J. Wright upon the "Harvest Bug" (*Trombidium Autumnale*), and which was illustrated by microscopic preparations. The paper described the appearance of the insects, their habitat, and habits as far as known, and considered that they were the young or immature form of some species of Tick. It was a common belief that the great irritation caused by the bite of these insects was occasioned by their burrowing under the skin; this, however, was believed to be erroneous, as no orifice could be discovered in the wales produced, nor was the insect provided with means for making an incision sufficiently large for the purpose. The wales closely resembled those produced by the stinging-nettle, in which also examination fails to detect any puncture; the inflammation in both cases being doubtless due to the injection of acrid fluid. Dr. Braithwaite thought that Lectis would be a more proper designation than Trombidium for these insects, the latter being that of the common red Earth Mite. He did not think that the fact of its having only six legs necessitated its being a larval form. Mr. M. C. Cooke said that although no further development was at present known, it was generally considered by entomologists that this was a larval form of some species of *Arachnida*, and that it belonged to the section *Trombididæ*, in which the larval form was hexapod. A species was known as commonly parasitic upon Tipulæ and Dragon Flies; this had six legs, and was the larval form of an insect which in its perfect condition was purely aquatic. He entirely differed from the opinion that the Harvest Bug was a larval form of Tick; for although in this state the Ticks were hexapod, yet they so closely resembled the perfect and octopod insect that there could be no doubt on this point. Mr. Arnold remarked the circumstance that the Harvest Bugs commonly bit persons under ligaments, or wherever there was a pressure from any article of dress. Mr. McIntire suggested that it would be an easy matter to settle the question of the identity of this insect with the young of the Earth Mite, which was very abundant, laying eggs in March, which were hatched in June.

Mr. Wight read a short paper "On the Use of Reade's Prism as a Polariscope," the mode of application being exhibited in the room. The Secretary introduced to the notice of the club a new form of microscope for aquarium observation, the invention of Mr. J. W. Stevenson. The instrument consisted of a bar of brass fitted with clamps for firmly fixing across the top of a tank; on this the mounting of the microscope tube was so arranged as to slide from end to end as required, and by means of two jointed motions could be directed to any portion of the tank, the adjustments for depth and focus being

* Report supplied by Mr. R. T. Lewis.

accomplished by a slide. A glass tube, closed at the lower extremity by a piece of thin covering-glass, was attached to the mounting, and the tube of the microscope being placed inside this, the instrument could be efficiently used without any portion of it coming into contact with the water. It was announced that a class for the study of Biology would be commenced in October by Dr. Braithwaite; and Mr. Suffolk intimated his willingness to repeat his course of lectures upon Microscopical Manipulation. The proceedings terminated with a *conversazione*, at which many objects of interest were exhibited, amongst which some very beautifully executed coloured drawings of magnified insects by Mr. Richter deservedly attracted much attention.

Old Change Microscopical Society.*

September 24th.—The President, Charles J. Leaf, Esq., F.L.S., in the chair.

The new session of the Society was inaugurated by a lecture on "Deep-sea Dredgings from the Shores of China and Japan," by Professor T. Rymer Jones, F.R.S., &c.

The lecture was illustrated by several mounted slides prepared by the Professor, and presented by him to the Society.

The thanks of the Society were unanimously accorded to Professor Jones for his interesting and instructive lecture, and for his donation of slides to the cabinet of the Society.

Mr. Piper called the attention of the Society to a new and useful *strainer* for collecting-bottles, by which the contents of several can be condensed into one, the *surplus* water passing out through wire-gauze. The apparatus is very portable, and is devised and made by Mr. Maginie, of 37, Queen Square, Bloomsbury.

Several interesting objects were exhibited at the *conversazione* which followed.

October 15th.—Chas. J. Leaf, Esq., F.L.S., F.S.A., &c., the President, in the chair. There were about sixty members and visitors present. Mr. J. R. Jackson, A.L.S., Curator of the Botanical Museum, Kew, delivered a lecture on "How a Plant Grows," which he illustrated by numerous sections of wood, prepared specimens of vegetable structure, and diagrams.

Mr. S. Helm, F.R.M.S., the Hon. Sec., read a paper "On what I saw at Walton-on-the-Naze," containing remarks upon the structure and habits of the *Actinia*, *Cydippe pomiformis*, *Noctiluca miliaris*, *Laomedea geniculata*, and the *Pycnogonidæ*.

The thanks of the Society were given to Mr. Jackson and Mr. Helm.

At the *conversazione* which followed, amongst other objects exhibited, were the new Polype (not yet named), from the Victoria Docks, by Mr. C. J. Richardson.

Fredicella sultana, by Mr. Helm, who also exhibited a collection of fossil shells from Walton-on-the-Naze, from the *Red Crag*, and presented duplicates of them to the Society.

October 22nd.—The President in the chair. Professor T. Rymer

* Report supplied by Mr. S. Helm.

Jones commenced a second course of ten lectures on "Comparative Anatomy," beginning this course with the Crustaceans.

The Professor took a lobster as a type of the family, and dissected it, explaining its various parts.

Brighton and Sussex Natural History Society.*

October 14th.—The President, Mr. T. H. Hennah, in the chair. An evening for the exhibition of specimens, when a variety of ornithological, entomological, and botanical specimens, many of them very rare, were exhibited by various members; but nothing relating to microscopical science was introduced. It was announced that Mr. Smith would read a paper at the next meeting "On the Mosses of Sussex."

Oldham Microscopical Society.†

On Tuesday evening, October 12th, the quarterly meeting of this Society was held. There was a good attendance of members and friends. A paper "On the Microscope in Geology" was read by Mr. John Butterworth. After referring to the usefulness of the microscope to students generally, Mr. Butterworth proceeded to state that by its aid the geologist was enabled to trace the various phases of animal and plant life existing through the different geologic ages, from the lowest Silurian up to the present, and that the important discoveries made through its agency have given a great impetus to, and interest in, the study of fossil remains. Its use in ascertaining the characteristics of the crystalline, stratified, and fossiliferous varieties of rock, was described at considerable length, and illustrated by numerous beautifully-prepared specimens.

The most interesting part of the paper was that which treated of the fossiliferous rocks, sections of which, from the Dudley limestone and from the Yoredale rocks in the Hebden Valley, were exhibited, showing the internal structure of the corals, zoophytes, goniatites, sponges, &c., of which they are composed.

Special attention was called to the fact that the coal-fields of Lancashire and Yorkshire are remarkably rich in fossil plants and fish-remains, and that in no part perhaps were more interesting specimens to be met with than in and around the town; some of which, gathered and prepared by various members, including teeth and scales of fishes, coprolites, and fossil wood, were shown under the microscope, by which the details of structure were brought out with remarkable distinctness.

Mr. Butterworth fully described the method by which sections for the microscope may be cut and prepared by the amateur at but little cost beyond time and patience. At the close of the paper, an interesting discussion took place on the merits and peculiarities of the various objects exhibited, which added greatly to the information and interest of the meeting.

A vote of thanks was unanimously accorded to Mr. Butterworth for the valuable information communicated.

* Report supplied by Mr. T. W. Wonfor. † Report furnished by Mr. R. Horne.

Bristol Microscopical Society.

Wednesday, October 20th, 1869.—The first meeting of this Society for the session was held on this evening, Mr. W. J. Fedden, President, in the chair. There was a large attendance of members. The formal business having been transacted, Dr. C. T. Hudson read a paper "On Black-field, Opaque, and Oblique Illumination, exhibiting some of the latest contrivances." The effects produced by means of Reade's Prism and Wenham's Truncated Lens were shown, those with the latter being particularly fine. The author then described a new mode of dark-field illumination which he had devised, by means of which large objects—such as entire insects—might be viewed under comparatively high powers. The effect produced by this method was very beautiful, and excited the admiration of every one present.

Mr. F. R. Martin brought for exhibition one of Collins's new dissecting microscopes. The general opinion of the meeting seemed to be that it was an improvement upon most of the forms of dissecting microscope hitherto constructed.

A vote of thanks to Dr. Hudson terminated the proceedings.

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Beiträge zur Anatomie und Physologie von Herrn C. Eckhard. Giessen. Roth.

Bryotheca Europæa. Fasciculus 22, von Dr. L. Rabenhorst. Dresden. Ebend.

Geschicte und Litteratur der Lichenologie von den ältesten Zeiten bis zum schlusse d. J. 1865, von Herrn A. Krempelshuber. München. Kaiser.

Hepaticæ Europaeæ, von L. Rabenhorst und Dr. Gottsche. Fas. 34–47. Dresden. Ebend.

De quelques Erreurs ou Préjugés en Physiologie végétale; par M. C. Bachy. Lille. Danel.

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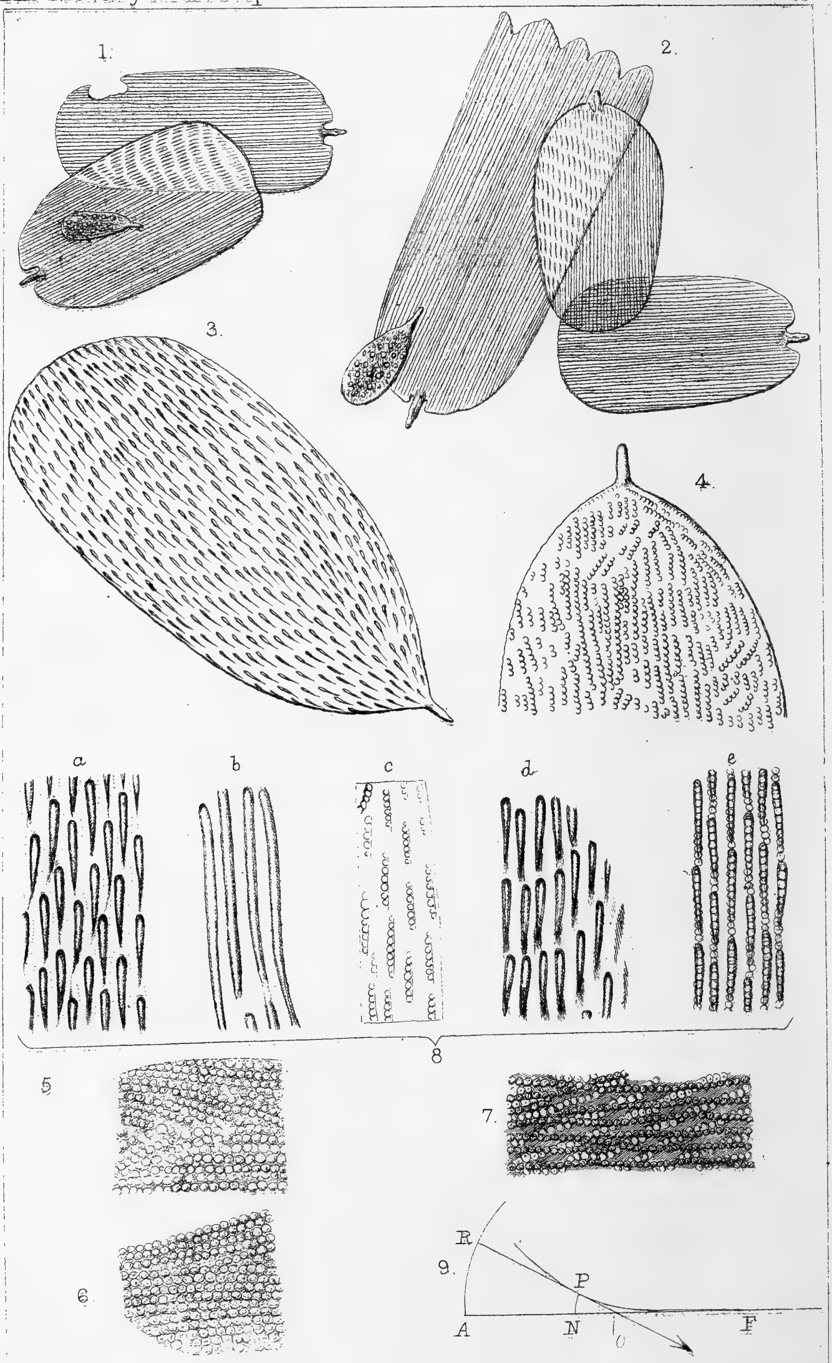
La Chambre noire et le Microscope: Photo-micrométrie pratique; par M. J. Girard. Paris. Savy.

Ueber die Embryonalhülle der Hymenopteren und Lepidopteren-Embryonen von Herrn M. Ganin. Leipzig. Voss.



Dr Pigott del. Tuffen West sc. W. West imp.

Podura Scales etc
(to illustrate Dr Pigott's paper)

THE

MONTHLY MICROSCOPICAL JOURNAL.

DECEMBER 1, 1869.

I.—*Further Remarks on the new Nineteen-band Test-plate of Nobert, and on Immersion Lenses.* By J. J. Woodward, Assistant-Surgeon and Brevet Lieutenant-Colonel U.S. Army. Contributed by permission of the Surgeon-General.

(*Read before the* Royal Microscopical Society, *October* 13, 1869.)
(Communicated by Jabez Hogg, Hon. Sec.)

The 'Quarterly Journal of Microscopical Science' for October, 1868, contains (p. 225) a short article in which I record the results of certain experiments made by me with the new nineteen-band test-plate of Nobert. In that paper I stated that I had obtained the best results with the $\frac{1}{25}$th objective of Messrs. Powell and Lealand, of London. The $\frac{1}{50}$th of these makers, which in my hands had excelled their $\frac{1}{25}$th on Podura and other test-objects, proved inferior on this plate, apparently because the cover of the object was too thick to allow the lens to do its best. With the $\frac{1}{25}$th I satisfactorily resolved the true lines of the fifteenth band of the plate; and subsequently my friend and assistant, Brevet-Major E. Curtis, Assistant-Surgeon U.S.A., prepared a series of photographs of the several bands, showing the true lines in each, from the first to the fifteenth inclusive. I was, however, unable to make out the true lines in the last four bands with any lens then in my possession. I conceived the idea, nevertheless, that if I could procure a test-plate ruled on a thinner cover, so as to give the $\frac{1}{50}$th full play, I might go farther. I therefore wrote to Nobert, who, after long delay, furnished me with a new test-plate, which reached me during March of the present year. This test-plate cannot be too highly praised for its delicacy and beauty. The lines are ruled on the under-surface of a square of thin glass the $\frac{1}{275}$th of an inch thick, which is cemented to a glass circle the $\frac{1}{110}$th of an inch thick. This circle is mounted over a round aperture in a strip of burnished brass 3 inches by 1, on which is inscribed the usual memoranda placed by Nobert on his nineteen-band plates.

It will thus be seen that the new plate not only permits the use of objectives of the shortest focal length known, but that it is also most favourably constructed for the use of oblique light or of an achromatic condenser of extremely short focus.

This plate was accompanied by an interesting letter from Nobert, dated Barth, February 26th, 1869, in which that skilful optician acknowledges the receipt of the photographs of the several bands, copies of which I had sent him, and, after speaking of them in a highly complimentary manner, admits that they exhibit the true lines up to the fifteenth band inclusive. He goes on to express his belief that the resolution of the higher bands is a physical impossibility, an opinion which he bases upon Fraunhofer's formula with regard to the spectra produced when light is permitted to fall upon closely-ruled parallel lines. "The formula $\sin x = \frac{\lambda}{b}$, if by λ we designate the length of the undulations, by b the distance between two lines of the grating, and by x the angle of the refracted rays, gives for $\sin x$ an impossible value when b becomes less than λ." Nobert further refers to his paper on gratings in Poggendorff's 'Annalen' for January, 1852, which those interested in the mathematical aspects of this question will find worthy of examination.

If the view taken by Nobert of the significance of Fraunhofer's formula is correct, the shortest wave-length in the visible part of the solar spectrum would appear to be the measure of the smallest dimension we can ever hope to render visible by means of the microscope; and it becomes, therefore, a matter of great interest to know whether he has rightly applied the formula, and whether it can be shown by actual experiment that the limit he imagines has any real existence. Nobert himself would appear to have entertained some little uncertainty as to his own deductions, for he writes:—"I am therefore very anxious to learn whether in resolving the lines of the test-plate we shall be able to progress beyond the fifteenth band. It would be a very important step, and one which would warrant the hope of the further improvement of the microscope."

After reading Nobert's letter, I sent it to my friend F. A. P. Barnard, President of Columbia College, well known for his studies in connection with the application of mathematics to optics, with the request that he would give me his opinion as to the application of Fraunhofer's formula to the question of the visibility of closely-ruled lines when observed under the microscope. Dr. Barnard replied in a letter, dated April 3rd, from which I make the following extract:—

"You will find a simple statement of all that Fraunhofer ever discovered on this subject, in my article in the Smithsonian Report for 1862, pp. 181–183.

"If parallel rays* from S fall on the grating G, at any inclination, the eye at E (perpendicular to the grating) will see a colour produced by the interference of the rays whose paths as reflected from the bars to E differ by half an undulation from the colour complementary. But this colour will not be seen unless the eye is at E. For other directions as F and F′ the interference cannot take place.

"The question is not, will these bars be coloured, but will they be visible. Nobert argues that when there is no colour, the complement to no colour, *i.e.* the whole light, must be suppressed. That is all I have ever been able to make of his argument or Fraunhofer's. This is not only theoretically not proved, but experimentally not true. It would be true both experimentally and theoretically in light positively monochromatic, provided the eye received only the perpendicular rays at E. But with an objective that takes in a cone of an angle of from 140° to 175°, it is nonsense to talk of this question as one settled by theory.

"We shall continue to see closer lines just in proportion as microscopes and modes of illumination are improved. Probably there is some physiological difference between individuals. All these images are faint, and keen eyes will see them better than dull ones. It would be a good test of the truth of Nobert's hypothesis to try, if, with a pure monochromatic red or yellow light, the thirteenth band of the nineteen-band plate is resolvable.

"On reviewing the table of wave lengths, and comparing with Nobert's statements as to the rulings of the nineteen-band plate, I am ready to affirm that, if his theory is true, not even the ninth band can be resolved in monochromatic yellow light."

At the time I received this letter from President Barnard, I had already resolved the sixteenth, seventeenth, and eighteenth bands with a new immersion $\frac{1}{16}$th, constructed for the Museum by Messrs. Powell and Lealand, of London, and subsequently I succeeded in resolving the nineteenth band with the same objective. With this lens a series of photographs of these bands were then prepared by Dr. Curtis. These accompany this paper, and will be presently described.

A careful count of the lines in each band gave the following results:—

15th band ..	45 lines	18th band ..	54 lines
16th " ..	48 "	19th " ..	57 "
17th " ..	51 "		

In obtaining the above results I illuminated the microscope, as in my former work on the Nobert's plate, with a pencil of mono-

* Colonel Woodward has sent no drawings for a diagram illustrative of these remarks, but as the meaning is tolerably plain to students of optics and the remarks are of import, we do not wish to excise the paragraphs.—Ed. M. M. J.

chromatic light obtained by reflecting the direct rays of the sun from a heliostat upon a mirror, by which they were thrown through a cell filled with a solution of the ammonia sulphate of copper, upon the achromatic condenser. As an achromatic condenser I substituted, for that belonging to the large Powell and Lealand stand of the Museum, a $\frac{1}{5}$th of an inch objective of 148° angle of aperture, and used it without a diaphragm; obliquity of light was obtained by moving the centering screws of the secondary stage.

I also obtained satisfactory resolution of the nineteenth band, with the same lens, by using for the illumination violet light, obtained by throwing the violet end of the solar spectrum produced by a large prism upon the achromatic condenser used as above, and subsequently by shifting the prism got successful resolution of the nineteenth band with blue, green, yellow, orange, and red light. These results I had the pleasure of exhibiting to Dr. Barnard and several others.

As for other lenses, carefully tried on the same plate, I obtained the following results:—

The $\frac{1}{8}$th of Wales and the $\frac{1}{25}$th and $\frac{1}{50}$th of Powell and Lealand, all dry lenses, resolved the fifteenth band, but not the sixteenth.

An immersion $\frac{1}{15}$th by Wales resolved the sixteenth band, but failed to go farther. An immersion $\frac{1}{20}$th by Wales resolved the seventeenth band, but failed to go farther. A Hartnack immersion No. "11," belonging to President Barnard, also resolved the seventeenth band, and failed to go farther.

A Tolles' immersion $\frac{1}{5}$th, just constructed for Dr. J. C. Rives, of this city, resolved the fourteenth band, but failed to show the true lines on the fifteenth. This result with the Tolles' immersion $\frac{1}{5}$th corresponds with the results very recently obtained with a Tolles' immersion $\frac{1}{6}$th, just received by my distinguished friend, Mr. W. S. Sullivant, of Columbus, Ohio, who wrote me May 25th of the present year:—"The immersion lens you inquired about, which Tolles sent me, was marked $\frac{1}{6}$th, but was only a strong $\frac{1}{5}$th English standard. The utmost it could do was to show true lines on the fourteenth band."

These results confirm the opinion expressed in my former article, that the lines claimed to have been seen, but not counted, in the nineteenth by a Tolles' immersion $\frac{1}{6}$th were spurious lines, an opinion to which still greater weight is added by the following result:—A Tolles' immersion $\frac{1}{10}$th of 175° angle of aperture was received at the Museum, May 26th, from Mr. Charles Stodder, who stated in his accompanying letter, that it might be regarded as a fair sample of Mr. Tolles' work. With this lens, after numerous careful trials, I was unable to see the true lines beyond the sixteenth band.

It will be seen, then, that in my hands the best definition was

obtained by the immersion $\frac{1}{16}$th of Messrs. Powell and Lealand; and I may here say, that on a thorough comparison of this objective with the dry $\frac{1}{25}$th and $\frac{1}{50}$th of the same makers, I found that not merely did their new lens resolve higher bands on the Nobert's plate than could be made out with the $\frac{1}{25}$th and $\frac{1}{50}$th, but that it would bear the use of eye-pieces and amplifiers so as to give higher powers than can be obtained with the $\frac{1}{50}$th, with much better illumination, with better definition, as well as with a practical working distance. The lens may therefore be especially commended for anatomical work when the highest powers are desirable.

In conclusion, I desire to remark on two points contained in the very interesting paper on "Immersion Objectives and Test-objects" by Mr. John Mayall, jun.*

1st. Mr. Mayall says:—"Dr. Woodward seems not to have been sure of the accuracy of the count he made on his photograph; for although in one part of his paper in the current (October) number of the Journal of this Society, he says the photograph shows the twelfth band as resolved into thirty-seven lines, farther on he says that forty is the real number in that band." This misapprehension on the part of Mr. Mayall arose from a misprint in the Journal.† On p. 231, fourteenth line, "12th band" reads in my original MS. "13th band;" on the thirtieth line of the same page, I find "12th band" printed instead of "19th band," which is the reading of the original. The same article contains some other singular misprints, most conspicuous among which may be mentioned, "Starting's work on the microscope," p. 225, instead of Harting's; and "Greenhap," p. 228, instead of Greenleaf. At the time my article was prepared, I had no doubt whatever of the true number of lines in all the bands resolved, except the fifteenth, about which, as I stated, I was uncertain whether the true number of lines was forty-five or forty-six. At present, additional work has satisfied me that forty-five is the number, and I am also well assured of the correct number as given above for the remaining bands. I freely admit that the difficulty of determining which is the last real, and which the first spectral line is very great even on glass positives; nevertheless, a comparison of several photographs with each other, and with the bands as seen in the microscope, has satisfied me that my count is correct.

The second point in Mr. Mayall's paper to which I desire to refer is the following remark:—"Dr. Woodward's photographs support an opinion given by Mr. Wenham many years ago, that the time would come when photography would reveal minute detail much more palpably than it can be seen in the microscope." If by this Mr. Mayall means that he has not been able to see the lines

* 'Monthly Microscopical Journal,' February 1, 1869, p. 90.
† 'Quarterly Journal of Microscopical Science,' October, 1868.

in the Nobert's plate as distinctly as they are shown in the photographs submitted, I must presume simply that he has not illuminated the object with monochromatic light as directed in my paper. Although certainly it must be admitted that the Nobert's plate is one of those objects in which the photograph most nearly approaches the beauty and detail of the original, and it must be of course apparent that a photograph will frequently contain details which in the microscope have escaped the observation of feeble or inattentive eyes.

In conclusion, I must say a few words about the photographs taken by Dr. Curtis, copies of which accompany this paper.

The original negatives were taken with the immersion $\frac{1}{16}$th, without an eye-piece, the distance of the sensitive-plate being such as to give as nearly as possible a thousand diameters. On these negatives, or on glass positives printed from them, the count of the lines may be made under a low magnifying power. Paper prints taken directly from the original negatives are very unsatisfactory, the texture of the paper interfering with the printing of such fine lines. On the other hand, enlarged prints lose so much detail that the difficulty of distinguishing the last real line in any band from the spectral lines on its margin, is so much increased as to make a satisfactory count impossible. I therefore send with this paper two glass positives; the first of which may be used for the study of the sixteenth, seventeenth, and eighteenth bands, while the second is especially intended for the nineteenth. I also send three paper prints enlarged to two thousand diameters, which will serve to show the general appearance of the lines, but which cannot be relied upon to guide in the count for the reasons just stated.

II.—*On High-power Definition: with illustrative Examples.* By G. W. Royston-Pigott, M.A., M.D. Cantab., late Fellow of St. Peter's College, Cambridge, M.R.C.P., F.R.A.S., F.R.M.S.

(*Read before the* Royal Microscopical Society, *November* 10, 1869.)

Plate XXXIII.

It is well known that the smallest visual angle subtended by a minute spot capable of being appreciated by the eye varies very much with the observer, even after proper adjustments have been made for long or short sight. The writer once tried the following experiment in order to determine the minimum visual angle. Receding from a pole, diameter $1\frac{1}{4}$ inch, elevated on a rising ground against the sky, it vanished at a distance of 1150 yards. The pole was capped with a black ball, to show its locality after the shaft disappeared. The angle subtended by $1\frac{1}{4}$ inch at 1150 yards' distance is about *six seconds of arc.* This occurred in 1834. In youth the eye is in general more sensitive, but the late celebrated astronomer, Mr. Dawes, retained surpassing keenness of sight to the last. To such, "definition" is a comparatively easy task with lower powers than to general observers. At a distance of a thousand yards our volunteers are taught that the head of a man sinks between the shoulders, and an appreciable visual angle is given by the bull's-eye at this distance of about $2\frac{1}{4}$ min. ($2'\cdot29$). These facts supply us with data for judging of the average power of definition.

Now suppose thirty or forty bull's-eyes in a straight line, painted black, in contact upon a white wall. Though 2 ft. in diameter, at a distance of a thousand yards only a black line would appear; the eye could not, unassisted, in general define the bull's-eyes of which it was composed,—or, in other words, definition of a line of round, black dots, each of about $2\frac{1}{4}$ minutes' visual angle, would fail. Perhaps if each centre were perforated with an inch aperture and illuminated from behind, their definition would be pos-

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DESCRIPTION OF THE PLATE ON HIGH-POWER DEFINITION.

Figs. 1 and 2.—Examples of diffraction and interference, producing a very perfect resemblance of Test-scale Podura markings by the intersecting beaded ribbing of two superimposed azure blue scales.

„ 3 and 4.—Sketch of Podura seen by direct condensed light and of longitudinal beading, with a few beads of the under-surface glimmering through the upper set.

„ 5 to 8.—"Admiration Test-scale." The general beading shows itself in a great variety of forms, according to the state of the illuminating pencils and the focussing upon the upper and under set.

„ 7.—The most perfect resolution hitherto attained by exceedingly patient and finely-adjusted glasses. The ribbing (*b*), Fig. 8, is here distinctly represented by darker beads of the upper rouleaus; the under-set always appear brighter in colour. Isolated beads, free from collateral interference rays, assume a natural resplendence and focal point.

„ 8.—*a*, *b*, *c*, *d*, *e*, different appearances of the test-scale under different conditions of illumination and vision. The ribbing (*b*) is preliminary to the transformation of the spikes of *a* into the rouleaus of *e*.

sible. In the case of double stars visible with Mr. Browning's $8\frac{1}{2}$-inch silvered specula (on favourable nights with 400 diameters), the closest I believe is Gamma[2] Andromedæ, $\frac{4}{10}$ seconds apart; this interval with 400 amounts to a visual angle of $400 \times \frac{4}{10}'' = 160''$, the smallest perhaps under which the eye can effectively divide and separate, not merely elongate, fine double stars; and but for the sparkling glory of these suns, so minute and dwindled in an abyss of distance, doubtless much closer stars (with instruments more perfectly free from aberration) should become visible. Only the finest known definition can sever those glittering points.

The healthy human eye, then, consisting of an achromatic combination of refracting media, and of a sensitive recipient of rays whose sensibility is limited to the minuteness of the distribution of its nerves, differs widely in its powers of definition, and particularly in its qualification of distinguishing a line from a string of dots each subtending an angle less than 2′.

The subject of definition is beautifully illustrated by the whole range of what are termed *line* test-objects, whether as the various pleurosigmata, striated scales, or artificial lines on glass, as Nobert's; the latter, however, being grooves cut or ploughed into glass by a fine, pointed diamond, cannot offer the same characteristics for definition as objects whose lines are caused by small, spherical bodies raised in relief, the complete resolution of which requires besides definition "penetration" (or less angular aperture than is necessary to catch the shadows arranged lineally upon glass). For these and other reasons the distinct definition and portraiture upon the retina of minute illuminated or *shaded* spherical dots, of small visual angle, placed in close contact, may be regarded as the severest known standard test both for the performance of microscopes and telescopes.

The disadvantages of deepening the eye-pieces in place of exalting the magnifying power of the object-glass or reflector, are at once so appreciable, in the appearance of haze, cloudy definition, and obscurity, caused by the increase of the "least circle of confusion," and the destruction of *aplanatism*, that great genius has been displayed in constructing object-glasses from $\frac{1}{16}$th to the $\frac{1}{25}$th and $\frac{1}{50}$th of an inch focus, whose performance has almost been regarded as beyond mere praise, entitling them to the highest honours which nations in their art exhibitions can confer. Yet in the best glasses there is a certain residuary aberration (chiefly spherical) which obscures the clear definition under a power of 1000* of a string of

* To find the visual angle (θ) of the 80,000th of an inch under a power of 1000 at 10 inches distance (the usual focal distance of the LAST image from the eye of the observer),

$$\text{Sine } \theta = \frac{\text{perpendicular}}{\text{hypothenuse}} = \frac{1000 \times \dfrac{1}{80000}}{10} = \frac{1}{800}.$$

Hence θ the visual angle $= 4\frac{3}{10}$ minutes nearly, or nearly double the visual angle of a two-foot bull's-eye seen at 1000 yards target.

beads less than 80,000 to the inch: whilst a visual angle of 6″ would represent an object whose diameter in the field of a microscope magnifying 1000 linear must be $\frac{1}{3460000}$th, or less than the 3,000,000th part of an inch. From this we can form some idea of the exceedingly minute character of objective aberration; even for a good $\frac{1}{8}$th object-glass it does not exceed the 50,000th of an inch.*

The extreme difficulty of defining a minute row of beads arises from the uncorrected aberrations confusing their images, by which several images overlap and obliterate the form of individual beads; still more is it increased if one set of beads be confused with the images of an underlying stratum of intersecting rows, forming a complicated beaded lattice-work, as in many interesting scales.

The Society will permit me to observe that I have found in the difficult enterprise of resolving the Podura scale into its component beads, the definition may be refined, partly by selecting such pencils of rays as pass through the lenses of the object-glass, so as to form an image with the most perfect aplanatism, or freedom from spherical aberration; all other rays causing haze and nebulous definition, and therefore with the least possible use of excentrical pencils of light such as emanate from ordinary condensers. In these high-power researches the integrity or perfection of the illuminating pencil of rays is as important as that of the refractions of the objective. In my experience I have found an oblique centrical pencil of aplanatic and achromatic cones of light of small aperture (15° to 20°) of the greatest practical utility, the obliquity being varied according to the object in view.

Another circumstance is worthy of note, *viz.* the position of the stigmatic image, or of the distance from the back lens of the object-glass where there is a *real* focus. If a precious stone of refractive index $\mu = 1 \cdot 6861$ can be found, such as is free from a double image, the equation for aplanatism

$$2\mu^2 - \mu - 4 = 0$$

will be satisfied if the gem be a plano-convex lens with the plane turned towards the object; the image would be formed without aberration. But till this can be found and worked, a search for the real focus or best image should not be neglected along the axis of the instrument.

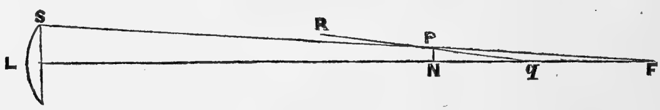
By elaborate calculation it appears that the variation of the distance between the front lenses of an object-glass produces a

* The aberration of lenses depends upon their general shape, and for illumination, crossed lenses should be formed into bull's-eyes.

Lenses.	Plano-convex.	Convexo-plane.	Equi-convex.	Crossed lens.	Crossed lens reversed.
Aberration	$\frac{405}{100000}$,	$\frac{105}{100000}$,	$\frac{150}{100000}$,	$\frac{96}{100000}$,	$\frac{310}{100000}$.

change in the aplanatism of the final image viewed by the eye-piece; it not merely makes a convenient adjustment for the errors caused by using different thicknesses of covering-glass, which varies from the $\frac{1}{100}$th to the $\frac{3}{100}$ths of an inch, but the index on the screw-collar may be used as a measure of spherical aberration occurring at the final focal image. The aberration sensibly changes for every different distance of the final focal image from the object, and consequently with the same object and covering-glass for differently-constructed eye-pieces.

The form of the caustic or curve whose successive tangents represent the aberrating rays passing through the last or back lens is exceedingly acute, almost approaching a straight line. If F be the focus for parallel rays passing through the lens L, and intersecting the axis at F; let Sq be the course of an aberrating ray intersecting the axis at q: and let it touch the caustic curve RPF at P; let FN = X and PN = Y. Then the square of PN is proportional to the cube of FN or Y^2 varies as $X^3 = NX^3$. And the aberration consists of two distinct dimensions. The lateral aberration is, in this case, represented by PN, and the longitudinal by Fq; it has therefore breadth and length. But lenses may be so combined that for a certain distance of q from L these aberrations can be reduced almost to nothing.



And it is possible to compensate practically one aberration by introducing another equal and opposite.

On these principles the investigation of the circumstances requisite for enhancing, clearing, or sharpening high-power definition may possibly be successfully carried out.

For a given distance of the object from the object-glass, the aberration caused by refraction through a plate of glass of thickness t is doubled or trebled, &c., by making the covering-glass twice or thrice, &c., as thick: but it also varies in a high ratio as the angle of aperture of the objective increases. In other words, the confusion of the final image is represented by multiplying the aperture by the thickness.

To define some of the most minute lines of diatoms fine definition is often sacrificed to enlarged aperture, which however gives the additional advantage of increased light.

It was only by very oblique and most skilful illumination that black-lined shadows could be obtained in the finest specimens and also by an aperture large enough to admit such oblique rays, that the lines could be seen at all: without this aperture, definition was of no avail with the power employed. Perhaps until a more exqui-

site standard for definition is realized than Nobert's lines and "lined diatoms" no great improvement will be made in the best object-glasses. The writer however ventures to express the opinion that a new standard for high-power definition will be found in the minute structure of the Podura scale, which affords the most severe trial for the correction of residuary aberration with which he is acquainted. And having given much leisure to the use of this interesting object in estimating definition and the possibilities of improvement, he prefers it to all others.

This extraordinary object, dating as a test from the jewel-microscopes of Pritchard and Dr. Goring to the splendid glasses of our eminent makers of the present day, has accomplished more towards the perfection of defining power than any other. It has done for the microscope what Sir William Herschel's close double stars and the rings and satellites of Saturn have done for the development of the charming and exquisite revelations of the telescopes of the time present.

The American Government has lately authorized the exhibition of photographs of several microscopical objects, taken by means of Wales' and Powell and Lealand's glasses: these sun-pictures, especially those by Powell's $\frac{1}{8}$th, $\frac{1}{25}$th, and $\frac{1}{50}$th, agree remarkably with the *accepted* appearances beautifully delineated in Dr. Carpenter's work and that of Messrs. Smith and Beck.

These photographs, taken by an American artist* and exhibited in England—might fairly be accepted as a challenge to English microscopists. But for this circumstance, the writer having awaited seven years for confirmatory evidence of his own results, now ventures to bring before the notice of the Society these observations: and in doing so he begs to remark that he believes they are capable of two kinds of demonstration, the *synthetic* and analytic, as far as the eye is concerned. But in order to obtain similar results, particular attention must be paid to the following conditions:—

(*a.*) Illuminating pencil.—A cone of light achromatic and *aplanatic;* angle of apex about 20°; inclination of axis of cone to plane of stage about 20° to 30°. The size of the condensing lenses employed is of no consequence, the other conditions remaining the same.

(*b.*) The scales which are darkest and smallest and with the longest diameter towards the light should be carefully chosen first with a good $\frac{1}{2}$-inch at 120 diameters.

(*c.*) The most patient *corrections* should be applied as to the object-glass, chosen distance of the secondary focal image, and the lenses for the eye-pieces; and lastly, the foci of the object-glasses and depth of the eye-pieces (so as to correct as much as possible the residuary aberration of the object-glass) should be most carefully selected.

* Colonel Dr. Woodward.

It is impossible within the limits of this paper to describe further in detail the arrangements found to be most successful.

It is well known that under a low power, as 80 or 100, the Podura is remarkable for its wavy markings (these are a safe guide in selecting the scale), aptly compared to "watered silk." It is here that the *secret* of their cause and nature is to be sought for: hitherto one which has baffled the most famous glasses of modern times. As a simple fact sometimes leads to a suggestion; view carefully against the light two pieces of the silk woven with the finest weft and warp placed one over the other: accordingly as one is lightly *stretched* more than the other or as the weft of one is inclined more or less to the weft of the other, instantly an endless series of waves are developed by the lines of optical interference: mesh intersecting mesh with infinitely varied effect: but always *waves.* Can the waves of the Podura be similarly caused?

Raising the power to 200 or 250 and using a side light upon our scale athwart its length, all waviness disappears, and in its place is seen a longitudinal *ribbing*, shaded very darkly; with a less oblique side light, lucid rhomboid chequers glitter brightly: the rhomboidal sides, crossing at acute angles, may be seen with a low power of 500. With 1200 these ribs have divided themselves into a string of longitudinal beads. But with 2300 they appear to lie in the same plane, and terminate abruptly on the basic membrane: upon focussing for the strings of beads attached to the lower side the beading appears in the intercostal spaces. The upper beads are best seen either green upon a pink ground or pink upon a greenish ground, which phenomena may possibly arise from the different dispersive powers or refraction of the various structures or the correction of the glasses; or even more recondite causes.

When the light is much more oblique, yet achromatic, the beads appear shaded as roughly represented in the diagram, the intervening spaces showing fine traces of intersecting lines.

Using now an adjusting $\frac{1}{2}$-inch at 250, and rotating the scales, some of the most favourable positions, with oblique light, inclined about 15 degrees to the axis of the scale, show a double set of longitudinal lines forming a lattice-work. These lines are the markings existing on the other side of the scale.

With 300 to 500 the celebrated "spines" appear, according to the size of the scale, as very dark short tapering marks (like "notes of admiration" without the dots ! ! !). To see these clearly with 2500 has been considered the *ne plus ultra* of microscopical triumphs, and it is consequently with no little diffidence that the writer ventures to traverse the belief of twenty-five years. The object of this paper is to show that definition can be further improved under the use of high powers, and if he should succeed in accomplishing this, the leisure of some years will not have been

spent in vain. It may be here observed that the adjustment of the correcting screw of the object-glass plays an important part in refining the definition, independently of the thickness of the covering-glass. I may observe that the first *six* illustrations accompanying this paper were effected by the anastatic process from drawings made direct from the microscope, in 1863, by a talented lady who is an excellent amateur painter, and who had no previous knowledge of the subject, and therefore wholly unbiassed.

Fig. 3. Is a rough sketch of the Podura spines illuminated by direct condensed light.

Fig. 4. Podura spines resolved into longitudinal striæ of beads with the lower striæ on the under-side of the scale partly visible.

Fig. 5. A rather exaggerated drawing illustrative of the size of the beads, but correctly giving the appearances of interlacing lattice-work formed by the upper and under ribs of beading crossing each other.

Fig. 6. Shows the careful resolution into beading by using a long-drawn tube: on the left the waviness of the beading is remarkable; next are seen rows crossing at an acute angle, and on the right side a more regular display of beading running in straight lines.

Distrusting at this time (1863) this novel appearance, I repeated experiments hundreds of times on different scales, and sought earnestly for some synthetic proofs, which were finally found in the appearances (drawn by the same lady) caused by the intersections of the ribs of the finest and most transparent scales of "azure blue" in Fig. 1, and a coarser intersection shown at Fig. 2. The beads to be seen brightly and clearly in the fine scales of Fig. 1 require very careful adjustments, and the spurious spines *there* shown, counterfeit, in every particular, the behaviour of the spines (which I shall also venture to call *spurious*) of the Podura scale.

When the light is almost direct, that is, the axis of the illuminating cone of rays is nearly perpendicular to the plane of the stage, the beads sometimes exhibit black dots, crescentic shadows, and brilliant points of light, according to the action of the transmitted rays upon their spherical surfaces. Similar dots may be seen upon the beads of the Pleurosigmata. Had we no visual direct proof of their sphericity, the symmetrical shifting of the crescentic shadows according to the direction of the light would prove their shape.

I may remark that the higher the power can be raised by lengthening the tube and deepening the eye-piece, consistently with a fine definition, the better chance will be afforded for distinguishing the upper and lower sets of beads crossing each other at an acute angle upon the upper and lower surface of the intervening basic

membrane; whilst on the other hand deepening the objective to gain power limits the focal depth or penetration; the amount of this depth even of a $\frac{1}{8}$th being exceedingly small.

By estimation comparing these beads with those of the *P. formosum* of $\frac{1}{30000}$ inch in diameter, the observed Podura beads may be reckoned at $\frac{1}{50000}$th to $\frac{1}{150000}$th of an inch in diameter. The "spines" usually drawn really embrace in general three or four beads, whilst the intervening spaces abound with beads seen through the basic membrane, and very difficult of observation without special management.

750 diameters will show with fine definition and a long-drawn tube and good penetration, beaded striæ upon both sides of the scale when coarsely marked.

1800 with a $\frac{1}{8}$th and nearly direct light (which should be formed as free from colour and astigmatism as possible) will show in favourable cases chains of beads lying upon the upper surface.

I cannot here too strongly call attention to the beautiful phenomenon, which I have always endeavoured to obtain as a fine and reliable test of approaching aplanatism and heralding a fine definition. In examining striated bodies—longitudinal bands glisten with a ruby tint upon a green or yellowish green ground. The bands appear like pellucid semi-transparent cylindrical ribs, and the flashing of these bodies with a ruby glow is a signal in my experience that the aberration approaches its minimum; when the beading dispels the mist and haze always accompanying the spurious "spines."

With a power of 2500 the beading may be seen to terminate abruptly, and commence abruptly near the edge of the scale.

The most difficult definition is that of the substratum of beads glimmering through the membrane nearest the light; on the other side they are generally of a very bright yellow-green colour, contrasting prettily with the deep ruby colour of the upper beads.

Availing myself of the aplanatic test above described, and focussing carefully the upper surface of the following tests, I have had the rare pleasure of seeing the manner in which the structures of several beautiful objects are arranged.

A. Battledore scales of azure blue.
   The whole surface is beaded over: the large beads seen with a $\frac{1}{2}$-inch are formed of a mass of strings of beads crossing and recrossing.

B. Fine transparent and smallest striated scales of azure blue.
   The upper ribs appear as distinct ruby-coloured beading; between and beneath which are seen *partly obscured* longitudinal rows parallel to and immediately behind the upper set.

C. The translucent ribbing of *Lepisma Saccharina* is formed of regular beads, and beneath these and radiating from the *quill* are lines of smaller beading crossing the upper set in straight lines. I see these yellow-green, whilst the upper set are brownish red.

D. By gas-light I observed rows of red spherical beads, placed upon the surface of the test-object, marked by the preparer of the scale *S. Hippocampus*,* alternating with yellow-green rows, somewhat encroached upon by the upper sets; all running parallel to the axis of the scale. 4000 diameters.

E. The surface of metals and alloys, with a power of 1000 diameters, shows, under reflected light, particles apparently spherical, agglomerated together, with dark lines separating the particles.

N.B.—Diffraction-rings similar to those observed about minute stars are abundant for single particles (scattered on paper by gilding) in proportion as the spherical aberration is less perfectly corrected, but which disappear when the aplanatism is established.

Query.—Are the diffraction-rings of stars due to the undulatory theory of light, or to the residuary uncorrected aberration of telescopic object-glasses?

Note.—The perfect definition of a broken surface of metal is a more severe test of aplanatism than artificial globules of mercury.

I may now, perhaps, be permitted to present to the Royal Microscopical Society synthetic evidence of the structure of the Podura, which appears to me to satisfactorily account for the peculiar, and I may say, embarrassing phenomena attending the study of the minute structure of this precious scale.

I beg particularly to call attention to Figs. 1 and 2. A careful search with a power of 150 among the scales of *Polyommatus Argus*, or Azure Blue, always found among the Battledore scales, of which, indeed, there are several kinds, will be rewarded with appearances which present the characteristic waviness or watered-silk appearance so peculiar to the Podura scale under low powers. These drawings, made in 1863, elucidate the cause of the Podura markings. With high powers, as 1000 to 2000, these scales show similar beading, and we have here a perfect example of a spurious spine being formed by lines of interference and diffraction; the beading being obliterated in the blank spaces, and dark markings or spines presented, precisely as is the case in the celebrated Podura scales. To my own mind this synthetic formation of the Podura markings is perfectly satisfactory and conclusive.

* This diatom is a specimen of *Pleurosigma Strigosum*.

I wish to add here that Mr. Browning pointed out to me that the beading of the Podura was rather unequal, some of the beads being larger than others. This is exceptionally the case; but I have found in numerous observations a great regularity in the size of the beads on the same scale.

They are most perfectly seen when the axis of the cone of light coincides with that of the objective, and the cone of light from the radiant is of very small aperture.

Extract from a Letter to the President.

October 1.—I feel firmly convinced that within a few months the Podura beadings, such as I have described them, will be thoroughly established. I purposely delayed publishing my results in 1862, hoping that further advances might be made in improving definition, and this has unquestionably been done by the *immersion lens,* which I have used this year with a Powell and Lealand's $\frac{1}{16}$th. With this lens I have been able to confirm the observations of former years in scales and objects of extreme difficulty. Before using this lens, I had succeeded in gaining a new intensity of definition in the *dry way*, and in balancing the uncompensated residuary aberrations; and I have used the Podura scale as a very exquisite test of the lenticular corrections, though there are other tests of a higher order still.

I have endeavoured also to improve the definition of the immersion lens by extraneous compensation.

Beck gives a very beautiful steel engraving of the test-scale under 1200 diameters. The spines are precise, and exhibited, as he saw them, and as thousands still see them, and as Colonel Woodward photographs them actinically with Powell and Lealand's $\frac{1}{25}$th and $\frac{1}{50}$th. But very curiously, in the middle of Beck's work, there is an engraving of the Podura, described "*out of focus*," being a series of parallel bands, which Mr. Aldous has drawn for me with the camera lucida under 4000 and 2500 diameters. These bands, as I see them, are wholly composed of beads of the diameter of the band, the under-beads being out of sight.

The extraordinary difference between the performance of the Hydro-objective and of the Pneumo-objective (the plate of air or water making *enormous differences* in the aberrations of the glasses) must make it apparent to ordinary common sense that our old-fashioned glasses are *wrong somewhere*, and if not in failing to converge the image of a point to another point, I know not where to find it, *i. e.* in aberration,—chromatic aberration being more easily compensated. I know it is very difficult to throw aside the creed and belief of forty years, and I have hesitated a long time to bring forward my views, being perfectly convinced that there would be a *battle of*

the glasses to be fought, and the manner in which the subject of aberration has been treated amply justifies my apprehensions.

I point to the immersion lens as an irrefragible proof of the deficiencies of the corrections of old-fashioned glasses to grapple with some of the exquisite difficulties of microscopic research, and if my poor efforts shall in any way advance the excellence of defining power, especially in the higher range of investigations, I shall in the end feel amply rewarded. The work has been earnest and sincere.

NOTE.—Dr. Pigott desires to have it stated that this paper was sent to the Royal Microscopical Society on the 21st of May last.—ED. M. M. J.

III.—*The Development of Organisms in Organic Infusions.* By C. Staniland Wake, F.A.S.L.

Having made various experiments on the connection between animal and vegetable organisms in their lowest phases, a brief statement of them, and of the conclusions to which they lead, may not be without interest. A piece of a wine-bottle cork having been put into a small glass stoppered bottle of distilled water, two or three days afterwards, on examining the water under the microscope, I found that very fine filaments had been produced from some of the cork cells. There was no appearance of articulation in the filaments themselves, they having rounded bulging ends, by exudation from which the growth of the filaments was evidently produced. On the next examination I found that these had increased in size and length, and had become branched, and an approach was evidently being made to the cell formation. Numerous small round bodies were floating in the fluid, either separately or in masses, and there was the appearance of similar ones, either in the cells, visible through the transparent walls, or protruding from them. Some days afterwards, however, I observed on several of the stems clusters of these round bodies, resembling bunches of grapes, and at a later date some of them appeared to have become elongated and like bacteria, moved freely and irregularly, though slowly, with a jerking motion. Moreover, the cells of the fibre had become further marked, and many of them contained, or had attached to them, oval pieces of jelly-like substance. These became separated, and occasionally united in masses or chains, some of them afterwards becoming enlarged and more irregular in shape. Another curious development showed itself in a large mass of very fine filaments bearing small bodies, oval in shape, but somewhat elongated at one end. These were apparently infusorial germs, as they much resembled others developed at a later period which were clearly of this character. They were also, probably, similar to monad-like bodies which appeared to be contained in many of the cells of the fungoid growth. These "monads" gradually became active, and finally they developed into infusoria, like what I believe is an early phase of *Kolpoda cucullus*, many of them remaining for a considerable period attached by fine filaments. At the present moment the cork infusion displays all these various phenomena, animalcular life being very abundant, and there is the appearance of a new phase of vitality in the form of minute seed-like bodies, occasionally clustered together in large masses. I may mention that this cork fungus has much the appearance of the so-called "cholera fungus." The closest analogy, however, to these phenomena is to be met with in milk or cream. The changes observable in an infusion

of this kind I have described elsewhere in the following words:—"On examining a drop of diluted cream under the microscope, we find that its globules are of various sizes, and that the smaller ones have an extremely active movement. Moreover, if a small quantity of cream be placed in water, after a few hours these smaller globules are found to have become both more active and more numerous. In the course of some days a further change takes place, many of them having taken an elongated form, and finally the cream infusion is full of animal life of a very active character." It is at a later stage that the vegetation makes its appearance in a form exactly resembling, as I have already said, the fungus developed in an infusion of cork. There is the same formation of cells, and the apparent "budding out" from them of masses of matter resembling jelly. In another infusion these curious-looking bodies were apparently produced by elongation of the globules themselves, and they then amalgamated to form the fungoid stem. All the globules in this infusion, moreover, "sprouted," and thus gave rise to a fungoid growth. In the cream infusion also there is produced a kind of fruit on the fungus—spherical bodies resembling the original "oil-globules"—and infusorial forms similar to those met with in the cork infusion are finally produced. This fungus appears to be a species of *Ascophora*.

These are the phenomena to be accounted for, and to simplify the matter I shall first of all state the conclusion I have arrived at as to the true explanation of them, and afterwards support this conclusion by other facts which have come under my own observation. The data are, simply, that, in the one case, from a vegetable substance—cork—and, in the other, from an animal substance—milk—both vegetable and animal organisms have been derived in such a manner as that we must suppose the higher to have sprung from the lower organism. We are, in fact, in the presence of the phenomena now explained by an increasing number of men of science as the result of "spontaneous generation," as it is popularly called, or by virtue of what is scientifically termed *heterogeny*. I shall have a few remarks to make on this hypothesis shortly, and I will say here only that, as usually understood, this hypothesis will *not* explain the phenomena in question. Decomposition is absolutely essential to "spontaneous generation," while here, so far from there being decomposition, every step in the process is an evolution of vitality. If we take the infusion of cork, we find that the fine filaments first developed can be traced distinctly to the cork cells, and yet these cells remain, apparently, intact, and they may be seen in the infusion undecomposed to the end of the experiment. The development is evidently from the *cell-contents*, whatever these may be. Moreover, all the further changes which take place present themselves simply in the course of this development. The

filaments increase in size and length. Their substance is gradually formed into cells, from which are thrown off certain bodies, some of which, with others of analogous character but probably of a different origin, finally and unmistakably take the infusorial form of life. The whole progress is an evolution of vitality. Exactly the same course is pursued in the changes which take place in a cream infusion, except that the organic so-called "oil-globule" is the starting-point in the phases of evolution. But if we reject the hypothesis of "spontaneous generation," or *heterogeny*, what other explanation of the phenomena can be given? It cannot be said that the germs of the fungoid growth, or of the infusoria, are introduced with the air or the water used in the experiments.* The phenomena in question completely negative this idea. Nor can we suppose that the germs of all the products are contained in the infusion itself. There is, certainly, a starting-point to which all may be traced—the contents of the cork cell in the one case, and the cream-globule in the other—but this accounts for the appearance of the first step only in the series of changes. Driven thus to a corner, the only conclusion we can draw is that the first germ is alone necessary. Given the cell-contents or the cream-globule, all the rest of the phenomena, whether they relate to animal or vegetable life, must inevitably follow, when the proper conditions of development are supplied.

In support of this view, I will now detail other experiments I have made, first, however, referring again to the fungus of the cork infusion. This we have seen was developed, apparently, not from the material of the cell walls, but from the cell-contents. Not that the cell necessarily loses its vitality immediately it becomes what Professor Beale terms "formed material." In the experiments above detailed, the cells give forth certain vital products in the course of the development of the fungus quite independent of the germs from which the infusorial life is evolved. It may be that these products themselves again combine immediately to form a vegetable structure, as I have seen several of them united endwise, and some at least of the milk-fibres had every appearance of being composed of cells thus joined and amalgamated. The cell-contents, however, are clearly the starting-point of the phenomena under review, judging from other phenomena to be now mentioned.

In France, M. Bechamp † has made experiments which establish "the natural development of bacteria in the protoplasmic parts of various plants," and he affirms that this arises from the fact that the *microzymæ*, or molecular granulations of the plant-tissue, are the germs of the bacteria. This opinion I have confirmed by the following experiments:—If a thin section of the tissue of a plant,

* We must dissent from this proposition of the author's.—Ed. M. M. J.

† See 'Popular Science Review' for April, 1869.

more especially that of the leaf or flower, be examined under a microscope, it will be found to contain very numerous small spherical bodies, having apparently a free movement, these being the *microzymæ* referred to by M. Bechamp, and among them bacteria also may sometimes be seen. Moreover, if a green leaf be moistened and rubbed on a glass slide, a number of these living molecules—monads or bacterial germs—are found on the glass when it is viewed through the microscope. I have seen them come from a small piece of leaf-tissue in a perfect stream. The cells of the petal contain great numbers of these bodies, and occasionally here, as in the leaf-tissue, blotches which appear to consist of masses of them may be observed. These facts led me to examine the seeds of certain plants, when I was astonished to find *microzymæ* in great abundance, more so than in either the petal or the leaf-tissue. In fact, the contents of seeds having a "fleshy" perisperm appear to be made up almost entirely of *microzymæ*, with occasional bacteria. To see whether these were really what I suspected them to be, I placed some seeds in water, and after a few days the water was swarming with most active infusoria of different kinds, including that which I have described as a phase of *Kolpoda cucullus*. On examining the contents of the seeds themselves the same phenomenon presented itself. In one instance the bacteria had a most curious appearance. A number of them were joined together end to end, and the united body moved actively through the fluid with a peculiar undulatory motion.

In a letter in which I communicated some of these facts to 'Scientific Opinion,' I stated that the pollen of plants seems "to consist literally of *microzymæ* cells," and that I had found the organic germs contained in these cells to move freely. This motion I have repeatedly witnessed, and, on one occasion, several of the pollen-cells of the common dandelion burst while in the microscopic field, and their contents were discharged and moved freely through the fluid in the same manner as the *microzymæ* of seeds. I was much struck with the resemblance between the organic molecules of the dandelion pollen-cells and those of the nettle, which I was examining on the same occasion, and I have no doubt that infusions of them would furnish similar results in either case. It is difficult to obtain the molecules of the nettle-hair without the tissue of the hair itself, which renders experiments with them less satisfactory than those with the contents of pollen-cells. The phenomena presented by the pollen when placed in water are most curious, and not the less so because these phenomena somewhat vary in different cases. A few days after placing some pollen of *Scabious* in water, I noticed a slight fluffy appearance at the bottom of the bottle. On examining this with the microscope, it was found to consist of minute filaments of a fungoid

growth, apparently from some of the pollen-cells. These filaments closely resembled the fungus of the cork infusion, and the subsequent evolution was also the same in the formation of cells, the exuding from them of bodies resembling pieces of jelly, and finally the development of infusoria. The only difference is in the character of the infusoria, which in this case have the form of *Paramecium caudatum*, rather than of *Kolpoda cucullus*, phases of which present themselves in the cork infusion. There is afterwards a development of other forms, especially a light-coloured spherical body, which spins rapidly through the fluid, and which is similar to organisms I have found in infusions of coal matter. The pollen of *Escholtzia* differed in its products from that of *Scabious* in the absence of the fungoid growth. Instead of the fluffy appearance, the bottom of the bottle was covered with a carpet of yellow substance, which adhered firmly to the glass. On examining a portion of this substance with the microscope, it was found to consist of the pollen-cells, which were apparently united by the interlacing of very fine fibres developed from them. There was, however, the presence, almost from the very first, of the same kind of infusoria as those which were finally developed in the other pollen infusion. One kind, unlike the others, was characteristic of both infusions, and I was much struck by its peculiar character, not having met with it elsewhere. It was very simple in appearance, resembling a short thick worm, without, however, any wriggling in its movements. Other pollen—that of the *fuchsia*—which I have tried, yielded results similar to those of the *Scabious*, in the development in the first place of a fungoid growth, the ultimate phenomena being the same as in both of the preceding cases. In this infusion, however, there was an extraordinary development of the spherical bodies which were produced, though in a less quantity, from the other pollen. These results are perfectly confirmed by the phenomena observed when the contents of the *anther*, which has been kept in water some time, are examined under the microscope. If the anther be crushed on a glass slide, it will be found to contain, in addition to the tissue itself, a quantity of filamentous growth, and numerous infusoria of several different kinds. In one instance I was surprised to find what appeared to be a perfect example of *Desmidiaceæ*, which was paralleled by the presence of a common species of *Diatomaceæ*, among the filaments of the infused Scabious pollen. I do not know how to account for the presence of these organisms in this curious situation. It may be that under the conditions named, they are sometimes developed; and on one occasion I undoubtedly found a broad fibre, having the exact appearance of an ordinary form of Desmidiaceæ, growing from a pollen-cell.

I have thus given a general idea of the phenomena attending my experiments, and, in conclusion, I will shortly notice their bear-

ing on the hypothesis of "spontaneous generation," or *heterogeny*, and state more fully what I believe to be the true explanation of them. When treating of the fungus of the cork infusion, I stated that the cell, from the contents of which the fungus spread, apparently remained intact. In the case of the pollen exactly the same thing is shown. Whatever organic development takes place, the material of the pollen-cell, or shell, itself remains in the same state, so far as can be ascertained. This agrees with what takes place when leaf-tissue is experimented with, the *microzymæ* from it being quite independent of the material of the cells themselves, which float about in the fluid after loss of their contents. This fact appears to me to prove conclusively, what all my experiments have tended to establish, that the organic evolution of which I have given details is not due to any process of *decomposition* of the organized substance. If so, however, it cannot be the result of "spontaneous generation." One of the fundamental requirements of *heterogeny* is the existence of a putrescent body in contact with air and water. Without decomposition there can be no spontaneous generation or organization, but when this is given the organic products are supposed to show themselves spontaneously—that is, without derivation from a pre-existing germ, even in the substance itself, which may, M. Pouchet declares, be reduced to charcoal, before it is infused, to ensure the destruction of all organic life. To me, however, such a notion as this is perfectly inexplicable. If the infused substance does not itself contain the germs of the future organisms, and if its organic character be thus absolutely destroyed, what remains to impress on the infusion afterwards made with it that peculiar character which gives rise to the phenomena of so-called "spontaneous generation?" Nor is the experiment of boiling the infusion more satisfactory. For, surely, if boiling will not destroy that organic character of the fluid which is absolutely essential to its presenting the phenomena in question, this operation must be equally inocuous as against the organic germs that may be present in it, although invisible. In fact, the admitted phenomena of *heterogeny* disprove, so far as I can judge, the entire hypothesis. M. Pouchet says that the granulated *pellicule proligère*—"la plus élémentaire qu'il soit possible d'observer"—"est évidemment formée par des cadavres de Monades ou de Bactériums;"* and on the preceding page he says that this pellicule "est constamment formée, dès son origine, par d'infimes microzoaires." But whence come the first microzoaires? The heterogenist says that they appear spontaneously. But from what? Not from the fluid simply, since without the presence of the decomposing, or rather infused, substance, the phenomena would not show themselves. Not from the substance itself, adds the heterogenist, because "à l'état de dissolu-

* 'Hétérogénie,' p. 355.

tion complète dans les liquides qui la renferment, le microscope le plus perfectionné n'y démontre absolument rien." This, however, is the weak point of the hypothesis, which has that purely *negative* basis on which it is impossible to build with safety. Thus, it does not at all follow that the organic germs are absent simply because they cannot be discerned. It might as well be said that, before the invention of the microscope, infusoria themselves did not exist, since they were then invisible to the unassisted eye. The presence of a decomposing organic substance, however, shows clearly how these germs may exist in the infusion, although invisible, before the formation of the *pellicule proligère.* For although the substance itself may be so completely dissolved that it cannot be discovered, the particles of which it is composed must be present in the fluid, and if so, since there is nothing to show that they lose their organic character, why may not the germs of the future infusoria thus exist? In the infusions of vegetable pollen, well defined rings, which doubtless are examples of the organic *pellicule*, make their appearance long after the development of the fungi and infusoria.

The conclusion I have come to on this question, judging from the above experiments, is simply that the infusorial germs are identical with the particles of the decomposing substance of which the infusions are made. The monads and bacteria, whose *cadavres* make up the *pellicule proligère*, are exactly the same, in every respect, apparently, as the monads and bacteria which exist in the seeds of plants, and which give rise to the infusoria subsequently discovered in these seeds and in the water in which they are placed. Even the pollen-cell is full of the *microzymæ* from which the monads and bacteria of the tissue are formed, and infusoria are no less abundant when the conditions necessary for their development are supplied. To the same category, without doubt, belong the so-called oil-globules of milk, which also, as we have seen, furnish numerous infusoria. The character of these globules is shown clearly by their relation to the corpuscles of the blood; it having been proved that milk-globules, if injected into the arterial system, finally take the form and character of the blood-corpuscles, which may themselves probably undergo the same process of development as the former exhibit when infused.

In these various facts we see a connection between the animal and vegetable kingdoms much more fundamental than has hitherto been supposed. The peculiar position occupied by infusorial germs in the tissue, the pollen, and the seeds of plants, shows that the latter are absolutely dependent on the former for their development, if not for their very existence; and, in fact, it seems to me that whether the final result shall be animal or vegetable, depends wholly on the conditions under which such germs are brought to maturity. Their nature is probably allied to that of the infusoria

into which they will, in the absence of a vegetable organism, usually be developed, although under other conditions the appearance of a fungoid growth may ensue. Or, it may be said, that the development of the organic germs in question *may* end in the formation of infusoria, but that before reaching this point it may be arrested, there being simply the formation of fresh "germs," the substance of the original ones appearing from time to time as a fungoid growth, the cell-contents of which are supplied by the renewed germs themselves.

Many curious facts bearing on this subject have been recorded by microscopists. Such are the phenomena noticed by Dr. Hartig and Mr. Carter, the former of whom affirms that "Amœba may be produced by the transformation of the 'antherozoids' of Chara, Marchantia, or Mosses; and that, in their turn, they become metamorphosed, first into Protococci or other unicellular Algæ, and then into articulated Algæ."* There is no improbability in these changes, if the hypothesis I have advanced be correct. In fact, the phenomena observed by Dr. Hartig are perfectly analogous to those I have described—the development of low animal forms from supposed vegetable germs. I say "supposed," for the antherozoids of all the simple plants appear to me to be purely *infusorial* germs, and they may, I have little doubt, be as readily developed into infusoria as the contents of ordinary vegetable seeds. I have myself obtained the Amœba under curious circumstances. If *coal* be powdered and placed in water, a peculiar microscopic vegetable growth will, after a while, be found to have been developed, and still later numerous crystalline or jelly-like excrescences and tube-like protuberances which have a perceptible movement make their appearance. In an infusion of this description which I have had for several months, I have met recently with several examples of a beautiful form of Amœba, and also others of a much larger kind, which moved about among the coal vegetation, to which it adhered. At one extremity only did those changes of form take place which are necessary to the progress of the Amœba; there being towards the other a circular marking, probably the contractile vesicle, and forward movement being effected by the protrusion of a broad limb, or rather "lip," of a much lighter colour than the body itself, and at the margin of which I distinctly caught sight on one occasion of the vibration of small cilia. The development of this creature, unless it was introduced with the water of the infusion, which I do not believe, strongly supports the view I have taken that there is an intimate connection between the initial phases of animal and vegetable life.

* But see note in Dr. Carpenter's work on the Microscope, 3rd edit., p. 357.

IV.—*Further Remarks on the Plumules or Battledore Scales of some of the Lepidoptera.* By John Watson, President of the Microscopical Section of the Literary and Philosophical Society of Manchester.

Having on a former occasion (No. VIII., p. 73) drawn attention to certain peculiar scales belonging to the Rhopalocera division of the Lepidoptera, as serving in some degree for generic or specific classification, and having then limited my remarks to the Pieridæ and Lycænidæ, I now beg to state the result of observations made in other families.

In conjunction with my friend Mr. Sidebotham a complete treatise is in preparation, embracing the whole subject of these plumules; it is to be illustrated with several hundreds of figures; but the completion of the large number of plates necessary will occupy considerable time. The figures will be arranged in generic groups of all the species (or so-called species) which can be obtained, so that observers may judge whether or not the plumules of some differently-named species are identical.

In the first place, referring to the genus *Pieris*, already treated of, I desire to draw attention to a small group of species placed at the beginning of the genus, which display no plumules. There are four species, viz. *Thestylis*, an unnamed neighbour, *Clemanthe*, and *Autothisbe:* we have before seen that the plumules are the possession of the males only; now, while deficient in this peculiarity, these species have another of their own, *viz.* a strongly-marked serrated costal margin of the upper wings, easily felt by running the finger along the edge. A short time ago I drew Mr. Hewitson's attention to them, expressing a wish that they might be more correctly placed in a new genus. Mr. Hewitson had some time ago separated this group in his cabinet, and Mr. A. R. Wallace, who is at work on the *Pieridæ*, has done the same; and I was much pleased to receive from him lately an inquiry respecting the absence of plumules, showing that he attaches value to the subject. He

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EXPLANATION OF PLATES XXXIV., XXXV., AND XXXVI.

Plate XXXIV.

Fig. 1.—Euplœa Mindonensis.
„ 2.— „ Alcathöe.
„ 3.—Heliconia Melpomene.
„ 4.— „ Thelxiope.
„ 5.—Eueides Thales.
„ 6.—Colænis Dido.
„ 7.—Pieris Lycimnia.

Plate XXXV.

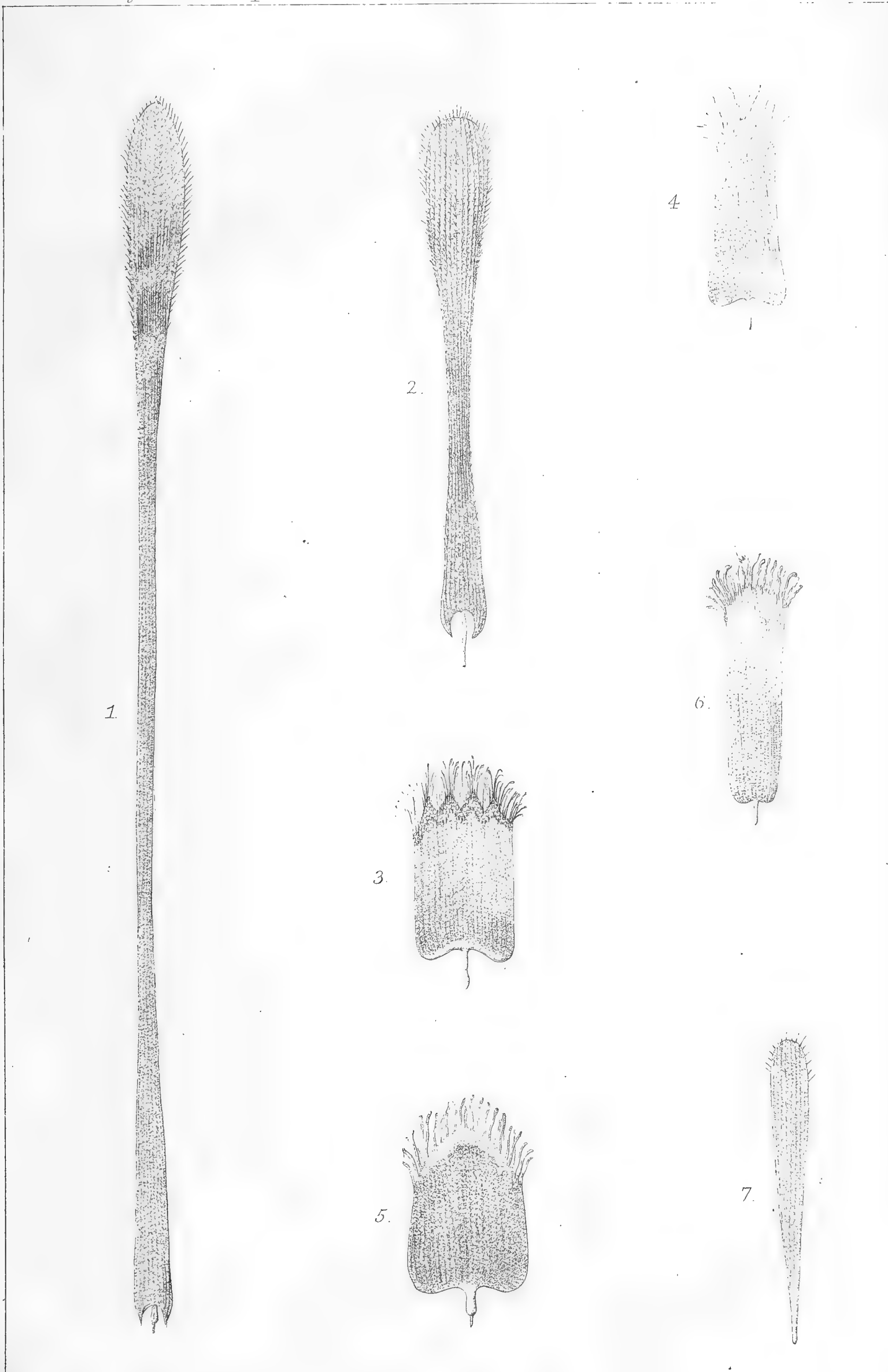
Fig. 7.—Agraulis Vanillæ.
„ 8.—Lachnoptera Iole.

Plate XXXV.—*continued.*

Fig. 9.—Argynnis Daphne.
„ 10.—Athyma Cama.
„ 11.—Taygetis Rebecca.

Plate XXXVI.

Fig. 13.—Euptychia Canthe.
„ 14.—Erebia Stygne.
„ 15.—Satyrus Beröe.
„ 16.—Argynnis Maia.
„ 17.— „ Aglaia.



Jos. Sidebotham del. Tuffen West sc. W. West imp.

Plumules of Lepidoptera.

proposes to call the new genus *Prioneris*, from the saw-like structure of the costal margin.* The only other species of *Pieris* which I have examined without finding plumules are *Agathon*, *Protodice*, and *Callidice*; the absence is very remarkable in the two latter, as their allies *Daplidice* and *Hellica* are abundantly supplied therewith.

There is a group of this genus to which I did not allude in my first paper, being then doubtful whether its scale could be considered a plumule—that is, of a character serving for distinction; such scales are very abundant on *P. Lycimnia*, *Flippantha*, *Isandra*, and some congeners, showing that these are perhaps all varieties of one insect. There is a figure of it on Plate XXXIV., Fig. 7; and great has been my surprise to find a somewhat similar form in some members of the Danaidæ family, to which further reference will be made; these have not the bulb-and-socket apparatus.

The interlinking of affinities, and the manner in which Nature loves to repeat her works with variations, are strikingly shown in the plumules generally; and throughout the different families there may be observed assimilations of form existing in widely-separated groups, just as is the case in the insects themselves.

Plumule is not an appropriate name for some of the forms of the scales which serve for distinctive classification; nor is battledore, which has been applied to those of the *Lycæna* genus; a more universal name would be better, proclaiming their private and peculiar property; and I would suggest Idiolepides (from ἴδιος private and peculiar, and λεπὶς, a scale); but we will at present continue the former term, plumules.

Before entering into a relation of the families and genera in which these objects are found, let me say something about them specially for microscopists. I have before described them as rotund or cylindrical; but a term suggested by Mr. Sidebotham, *viz.* bellows-shaped, is more characteristic and correct. It is manifest that, if the form of plumule of *P. Rapæ* were actually rotund or cylindrical, the peduncle and bulb would often, on a slide, be covered with the membrane; but, when mounted, the scale always shows the lobes on each side of the bulb, proving its, in some degree, appressed form.

Then, as to the parts of the insect where they are to be found: generally on the upper surfaces of the wings, sometimes most abundant on the primary, sometimes on the secondary; usually in or near the discoidal cells of both wings; but occasionally very strangely placed, as we shall presently see when referring to the genus *Euplœa*.

The best way of collecting and mounting is by gently pressing the wing of the insect against a glass slide, by which means a sufficient quantity of the scales will adhere: to get a clean mounting

* It is interesting to note that a similar serrated costa occurs in some species of *Papilio*, of *Charaxes*, and of *Gonepteryx*; and these are all without plumules.

it is necessary to brush off the dirt which may be on the wing with a camel-hair pencil; but then care must be taken that the pencil does not convey scales to slides of other species; and, in fact, suspicious care must be used when mounting a number of slides, as the light scales will often be floating in the air and alighting unexpectedly on the slide which is under operation. Then cover with a thin glass, and fix with paper. In some small insects it is more convenient to take off the scales in the first instance on the thin cover, and then to affix it to the slide. The plumules are mostly of so delicate a membranous structure, and so deficient in pigment, as to become too transparent (and sometimes almost invisible) in Canada balsam; but it may be used with good effect where they carry some amount of pigment; and the structure of those of the *Lycænidæ* is thereby beautifully shown, although these are among the most hyaline. In some genera and species they are so small and so finely striated as to make a $\frac{1}{8}$-inch object-glass desirable to resolve them satisfactorily, or at least a $\frac{1}{4}$, with a B or C eye-piece; while a $\frac{1}{2}$-inch is sufficient for others.

The striæ particularly should be observed with high powers. Occasionally scales of different species appear under a low power identical, but a higher one reveals a complete difference of structure.

Taking for our text-book the 'Genera of Diurnal Lepidoptera' of Doubleday, Westwood, and Hewitson, we proceed to state the additional families and genera where the plumules have been found. Throughout this work there is evidenced an inkling of the writer's appreciation of the value of the scales, or of some of them, for aid in classification, but more in the direction of genera than of species; and the distinct character of the plumules is not recognized, nor the probability remarked that the insects are furnished with two classes of scales, as was suggested in a former article. In the consolidated treatise we are undertaking, we shall notice, *seriatim*, all the families and genera, with remarks on peculiarities of some scales, even when they do not assume the form of plumules.

In the work above named, the Diurnal Lepidoptera are divided into fifteen families.

Family I. Papilionidæ.—No plumules found.

Family II. Pieridæ.—Found on many species already mentioned.

Family III. Ageronidæ.—None.

Family IV. Danaidæ.—It is in the genus *Euplœa* only of this family that plumules have been found; and they bear a very different form from that of those of other genera, with the exception of an approach in *Pieris Lycimnia*, Plate XXXIV, Fig. 7.* The typical form of *Euplœa* is shown in Plate XXXIV, Figs. 1 and 2; and I have found them on thirteen species, whether or not all distinct may be

* The plates have been drawn by Mr. Sidebotham, specially for the illustration of this paper.

questioned, but there can be no doubt about the two in the plate. When the plates containing all the figures are ready, their similarities and differences will be apparent. It is to my friend Mr. Labrey's industry and information that I owe a knowledge of these plumules. I had often examined the insects unsuccessfully: and it well might be so; for these scales are not found in the ordinary places, but, as I believe, only in the upper part of the secondary wings, where overlapped by the primary and fringing the light-coloured patch on the inferior wings; here they exist in *Euplœa Midamus* in large and compact masses, presenting an appearance similar to a bed of bulrushes at the edge of a marshy lake. I cannot doubt that further search in this genus will be rewarded with valuable evidence as to the identity or difference of many species.

Family V. HELICONIDÆ.—Here I have been able to find plumules in the genus *Heliconia* only, but in twenty-six species. They are of singular interest in our view of their use for classification and for the determination of species.

Mr. Bates, in his 'Naturalist on the Amazons,' vol. i., p. 256, &c. (1863), devotes some pages to show that many species of this genus have had a common origin, proving the "manufacture of new species in nature." He takes "*Melpomene*, abundant in Guiana, Venezuela, and some parts of New Granada," as the original species, and argues that *Thelxiope*, "ranging 2000 miles from east to west, from the mouth of the Amazons to the eastern slopes of the Andes," is merely a local modification; and yet he says that "if local conditions, acting directly on individuals, had originally produced this race or species, they certainly would have caused much modification of it in different parts of this region; for the Upper Amazons country differs greatly from the district near the Atlantic in climate, sequence of seasons, soil, forest-clothing, periodical inundations, and so forth." He then proceeds to contend "that there is some more subtle agency at work in the segregation of a race than the direct operation of external conditions," and that the principle of natural selection, as lately propounded by Darwin, "seems to offer an intelligible explanation of the facts."

The plumules, however, enable an observer to detect without doubt the species: if those taken from any number of specimens of the species *Melpomene, Thelxiope, Aœde,* and *Vesta* are examined, each can be named; but mere varieties of each species will exhibit the same plumule, as in the case of *Thelxiope* and *Aglaope*. Surely, if the Darwinian theory were true, that a change is constantly in progress, we ought to find plumules of an undecided form in some specimens, partaking of and hovering between the characteristics of their supposed ancestors. With all deference to Mr. Bates, whose opportunities of observation have been great, I cannot but regard his theory as improbable and far-fetched. Why should *Thelxiope* have descended from *Melpomene* rather than the latter from the

former? and why suppose any necessity for derivation at all? Butterflies are often confined to narrow localities; and when species are widely spread in various geographical habitats, varieties occur; but the species continue recognizable, and the more specimens can be obtained the more certain is their determination. It is much more probable and philosophical to suppose that an intelligent Creator placed His creatures in such localities and conditions as suited their various requirements, and maintained them there; and, as Mr. Bates says, "a proof of this perfect adaptation is shown by the swarming abundance of the species."

This swarming abundance and teeming variety of life in the Amazons region is not confined to the insect tribe; for "Professor Agassiz, who has lately been engaged in examining the fish of that river, states that he has not found one fish in common with those of any other freshwater basin; that different parts of the Amazons have fishes peculiar to themselves; that a pool of only a few hundred square yards showed 200 kinds of fish (which is as many as the entire Mississippi can boast); and that in the Amazons itself 2000 different kinds exist."*

We must look in vain for specific distinction, if such different insects as *Heliconia, Melpomene,* and *Thelxiope* are to be regarded as of one common origin. Mr. Bates admits that "both are good and true species, in all the essential characters of species; for they do not pair together when existing side by side, nor is there any appearance of reversion to an original common form under the same circumstances."

Family VI. Acræidæ.—No plumules found.

Family VII. Nymphalidæ.—Found in the following genera:—

Eueides.—Here on five species they have been detected, and they bear a very strong similarity to those of the *Heliconidæ,* the insects themselves being also alike. A comparison of *Heliconia Vesta* and *Eueides Thales* would induce a casual observer to regard them as almost identical; but Mr. Hewitson† has pointed out "a difference in the position of the discoidal nervures of the posterior wing, as well as in the orange rays which proceed from the base of the posterior wing;" and he well says, "If a butterfly or a genus resemble another (though placed systematically at a distance from it), let it be in colour or in form, it may be expected to resemble it in other characteristics." The plumule of *Eueides Thales* you will see on Plate XXXIV., Fig. 5.

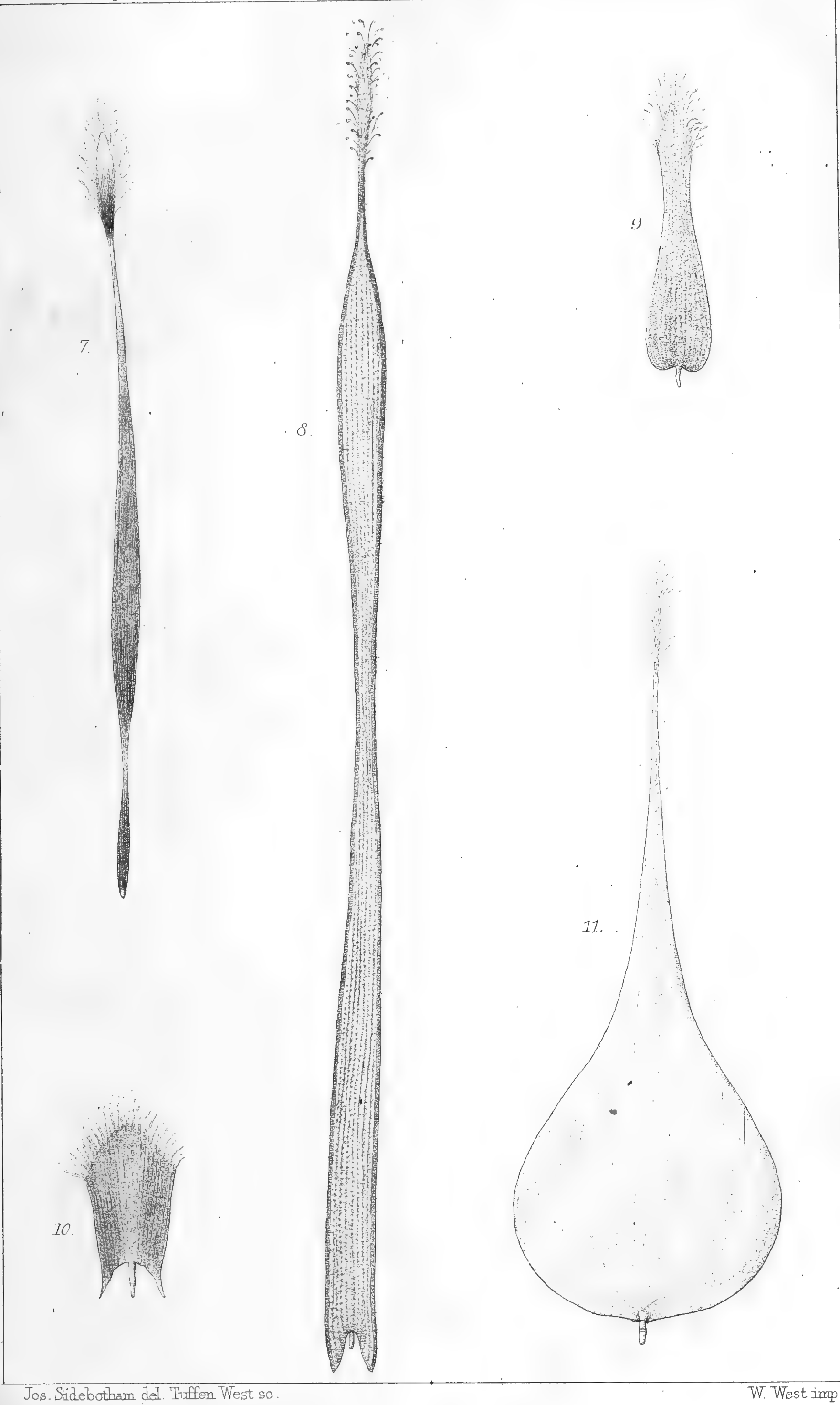
Colænis.—Found in five species, one of the forms being shown on Plate XXXIV., Fig. 6.

Agraulis.—Found in three species, introducing a very distinct type, which we shall see is, as it were, played upon and repeated with variations in other genera (Plate XXXV., Fig. 7).

Terinos.—On the two species of this genus which I possess

* 'Athenæum,' March 23, 1867.

† 'Journ. of Ent.,' vol. i., p. 156.



Jos. Sidebotham del. Tuffen West sc. W. West imp.

Plumules of Lepidoptera.

there is a very peculiar pear-shaped scale, not, however, I think, a plumule. I notice this genus here in its place because it possesses hairs of a bifid form at the apex, of a character similar to some which will presently be noticed under the genus *Argynnis.*

Lachnoptera.—This genus consists of a single species, "*Iole;*" and its very peculiar scale is shown on Plate XXXV., Fig. 8. It was noticed by Doubleday, who regarded it as probably of a sexual character, although he had never seen a female; nor have I. He describes it as "a hair-like scale, terminating in a vane, like the feathers of the raquet-tailed humming-birds."

Argynnis.—Plumules found on fifteen species. They have often been noticed by microscopists; and two were figured in the article by Deschamps, to which reference was made in my first paper. The type is shown on Plate XXXV., Fig. 9, and Plate XXXVI., Fig. 17. Besides these plumules, however, there are found on some species some plumule-like hairs, as shown on Plate XXXVI., Fig. 16. Many of the Lepidoptera possess fringes of long hairs, but with a simple pointed termination, while these have a large brush at the end. I doubt whether they should be regarded as serviceable for specific distinction; but further examination is desirable. It is strange that I have not succeeded in finding plumules on any individuals of the second section of the diurnal species of this genus, nor on any of the very closely allied genus "*Melitæa.*" These two genera have been much mixed together by entomological classifiers. Will the presence or absence of plumules serve for a permanent separation?

Athyma.—Plumules have been found on eleven species, a type being shown on Plate XXXV., Fig. 10. I have searched in vain for them on the closely allied genus *Neptis.* There has been great difficulty in the generic separation of this group; but perhaps hereafter the existence of plumules may aid classifiers with regard to the allied genera *Athyma, Neptis,* and *Limenitis.*

Eteona Tisiphone.—This insect, although placed among the Nymphalidæ in our text-book, belongs no doubt to the family Satyridæ, as is now generally admitted, and as its plumule would serve to prove.

Thus we see that in the large family Nymphalidæ plumules have been discovered in but few genera, and those principally of the sub-family Argynnidæ of some authors.

Families VIII. *and* IX. MORPHIDÆ *and* BRASSOLIDÆ.—No plumules.

Family X. SATYRIDÆ.—Here we have generally a well-marked type, subject, however, to many aberrations.

Corades.—Found in three species.

Taygetis.—Found in four species. Plate XXXV., Fig. 11, exhibits the form of the plumule of *T. Rebecca,* reminding us in its outline strongly of *Pieris Belladonna;* the striæ, however, are very different; and this group does not possess the bulb-and-socket apparatus.

Zophoessa.—Found in one species.

Euptychia.—Found in five species. See the singular form of that of *Canthe,* Plate XXXVI., Fig. 13, reminding us again, by its large lobes, of some of the *Pieridæ.*

Erebia.—Found in thirteen species. A type shown in Plate XXXVI., Fig. 14.

Chionobas.—Found in seven species. A most interesting northern group, principally inhabiting Lapland and Norway.

Lariommata.—Found in ten species, the forms of *Mæra* and *Megæra* having been figured by Deschamps.

Satyrus.—Found in thirty-two species. A type, *Beroë,* is shown on Plate XXXVI., Fig. 15. The plumule of *Janira* has long been known.

Families XI., XII., *and* XIII. EURYTELIDÆ, LIBYTHEIDÆ, *and* ERYCINIDÆ.—No plumules found.

Family XIV. LYCÆNIDÆ.—To these battledore scales I have before called your attention.

Family XV. HESPERIDÆ.—None found.

Having thus completed an account of observations already made, I annex a Table showing an approximate estimate of the number of species where plumules have been found to exist, and of the genera possessing them. Doubtless there is room for further research; and I would urge upon all a prosecution of this interesting study. I doubt not that among the Rhopalocera there will be further discoveries made; and the Heterocera afford an untravelled field to an observer. It will be very interesting to entomologists to learn whether any plumules are to be found among them, or any other class of scales serving for generic or specific classification.*

GENERA IN WHICH PLUMULES HAVE BEEN FOUND.

	Species.				Species.		
Euterpe, about	19			Athyma	11	—Nymphalidæ	45
Pontia	1			Corades	3		
Pieris	132			Taygetis	4		
Zegris	2			Pronophila ..	9		
Anthocharis ..	29			Debis	5		
Thestias	4			Zophoessa ..	1		
Hebomoia ..	3			Euptychia ..	5		
Eronia	11	—Pieridæ ..	201	Erebia	13		
Euplœa	15	—Danaidæ ..	15	Chionobas ..	7		
Heliconia	26	—Heliconidæ	26	Lariommata ..	10		
Eueides	6			Satyrus	32	—Satyridæ ..	89
Colænis	5			Lycæna	121		
Agraulis	3			Danis	9		
Terinos	2			Dipsas	1	—Lycænidæ	131
Lachnoptera ..	1						
Argynnis	17			30 Genera.	507	Total ..	507

* This article has been reproduced—with permission—from the 'Transactions of the Literary and Philosophical Society of Manchester.' The stones have been kindly lent by the author.—ED. M. M. J.

Jos. Sidebotham del. Tuffen West sc.

W. West imp.

Plumules of Lepidoptera.

V.—*My Experience in the Use of various Microscopes.* By Dr. H. Hagen.*

Having worked with the microscope more than thirty years for medical and scientific purposes,—following the gradual perfecting of the instrument—I was anxious to examine the power of American microscopes. But my occupation in the Museum and ignorance of the English language have prevented the accomplishment of my wishes. I ordered a new microscope of M. Hartnack in Paris, which was kindly forwarded to me by M. Milne-Edwards. The French instruments are noted throughout Europe for their power and finish, and in order to judge impartially, I chose one of these, rather than a German instrument. It is well known that nearly every nation claims for itself the highest degree of perfection in the manufacture of microscopes. No Englishman would acknowledge the superiority of a French instrument, nor a Frenchman that of an English instrument. In Germany alone, Prussian, Austrian, Saxon, and Bavarian manufacturers all claim pre-eminence for their respective instruments, not only compared with each other, but with those of American and English manufacture. There has been no unanimity of opinion among scientific men in regard to this question. I think these conflicting claims are based upon something beyond mere national pride. In fact, microscopes finished by the most skilful opticians, have arrived at a high degree of perfection in nearly every country, and differ less than is generally supposed. During the past ten years there has been great competition among opticians, but in every case their progress has been arrested by one insurmountable obstacle. Since the recent improvement in correcting the objectives for the thickness of the cover-glasses, comparatively little has been done. Indeed it is always stated and accepted as a fact, that the proper means of obtaining a stronger power consists in securing a higher power of the objectives and a smaller focal distance with greater angular aperture, and in this opticians have arrived at a rare degree of perfection. Objectives of $\frac{1}{50}$th in. are made, and the greatest angular aperture, so far as I know, is in the $\frac{1}{12}$th objective by Spencer, with 175° angular aperture. But even here further progress is arrested. The increase of the angular aperture increases the two aberrations to be corrected, and materially weakens the penetrating power. Judging from an examination of the test-plate of Nobert, it would appear that the best instruments of any country differ but little in power. It was stated, at a recent meeting, that Messrs. Stodder and Green-

* The following paper was read before the Boston Society of Natural Science on the 10th of March last. We reproduce it because it contains an interesting sketch of the qualities of different instruments not generally familiar to English workers.—Ed. M. M. J.

leaf had resolved the highest groups, a thing never before accomplished with any instrument. This statement, however, is doubted by their learned countryman, Dr. Woodward.

The test-plate of Nobert, dividing the inch into more than one hundred and twelve thousand parts, is generally adopted as a good test-object. But even here a very important consideration in forming a thorough and correct judgment exists, and is almost constantly overlooked; I mean the difference in the aberration of the eyes of the observers. There is no doubt that different observers obtain different results from the same instrument; of course a greater dissimilarity arises in the use of the same test-object with separate microscopes. All attempts to correct this personal aberration are still unreliable and unsatisfactory; therefore the microscopic photographs which are brought to so admirable a degree of perfection, are, in fact, the surest test-objects now existing for the power of an instrument.

Besides this personal difference there exists a very considerable one resulting from the continual use by each observer of one particular instrument. In this connection I recall the striking fact, that as the celebrated microscope of Leeuwenhoek arrived at the Royal Society in London after his death, no one was able to see the objects observed and described by him. An experienced observer will often see much better with his own imperfect instrument, to which he is accustomed, than another person would do with a far superior microscope.

Doubtless the most important matter for microscopical science is the price for which the instrument can be obtained. The cheaper the instrument the larger the number of observers. In Europe, ten years ago, about two thousand large instruments were manufactured every year; now the number is more than double. Surely for a physician, and for many other observers, an amplification of moderate size, from two hundred and fifty to three hundred diameters, is sufficient. Professor Ehrenberg, in Berlin—and I believe no living observer has made so much use of the microscope—uses almost constantly in his work an amplification of three hundred and fifty, and in some exceptional cases of seven hundred and fifty diameters. For histological purposes higher amplifications are necessary, but the physician and the naturalist will usually be contented with a good amplification of nearly three hundred diameters.

Every possessor of a microscope wishes to test the power of his instrument, but it is not, and never has been, my purpose to provoke competition between American and European microscopes. Certainly every step toward the perfection of the microscope is important, but when the improvements are so minute that they cannot be used and seen easily and everywhere, they are, I think, more interesting to the artificer than to the operator.

Indeed all over the world, first-class microscopes have resolved the fourteenth, or even the fifteenth band of Nobert's test-plates; but should it be found that American microscopes, even with a $\frac{1}{8}$th in. objective, have resolved perfectly the nineteenth band, the superiority of these instruments would be so enormous that it could easily be proved in any place and at any time.

I wrote to Mr. Hartnack to send me a first-class microscope for investigations in anatomy and natural history, and added that I intended to compare it carefully with the best American instruments. I did not fix the price, and left the choice entirely to him.

He has sent the instrument marked in his catalogue as No. VIII., a new small model, only differing from his great model by wanting the rack motion of the tube, by having but three eye-pieces, and by lacking two objectives of lower power.

The catalogue states that this new model, Hartnack's patent, differs materially in the optical and mechanical construction from his old Oberhauser microscope. I confess I have been unable to discover any difference, except that the fine moving screw is placed near the top of the tube instead of below. The sliding tube to be elongated by another tube has a diaphragm, which is also above the objective. The diaphragm under the stage may be removed by a sliding apparatus or by a sliding tube. The three eye-pieces, as in the Oberhauser instruments, have a low power, $2\frac{1}{2}$, $3\frac{1}{2}$, $5\frac{1}{2}$ nearly. The objectives are No. IV. $\frac{1}{2}$ in., No. VII. $\frac{1}{6}$th in., and No. IX. $\frac{1}{12}$th in., fitted for correction for the cover-glasses, and for immersion. Hartnack calculates the amplification for the first ranges from 70 to 480 with the lower eye-piece, and from 140 to 950 with the strongest. The camera lucida used with a fourth eye-piece goes up to 1000 times. The lowest eye-piece has a glass micrometer.

This instrument costs 390 francs, about 104·00 dols. in currency, and the camera and lens, 50 francs, about 14·00 dols.

The catalogue sent with the microscope gives numbers of the objectives from 10 to 18, or from $\frac{1}{16}$ to $\frac{1}{50}$ inch. The $\frac{1}{16}$ costs 200 francs (53 dols.), the $\frac{1}{50}$, 500 francs (134 dols.), and the other numbers vary accordingly.

The two stronger eye-pieces, 5 and 6, cost ten francs each. No. 5 magnifies $7\frac{1}{2}$ times. No. 6 is unknown to me.

My instrument is No. 8066. Nineteen years ago, in March, 1850, Professor Vrolik received from the same optician No. 1786. Since then he has delivered 6280 microscopes, 330 a year, or almost one a day. My instrument was received about six months after I ordered it.

The Section may be interested in seeing an old German microscope, made in Berlin by Scheck, in 1837, and used by me for many years. The defining power is even now sufficient, but the

penetrating power in all microscopes at that time was very low. In the old Nobert's test-plate of ten bands, it resolved the sixth well, but the seventh is doubtful .At this time Scheck's microscopes were considered the best by the most experienced observers, especially by Ehrenberg. I am sorry I cannot exhibit a microscope in my possession, nearly two hundred years old, and now in good order. I have watched with great interest the growing demand for these instruments, and the surprising increase in the number manufactured during the last thirty years. Long ago I made my first observations on the scales of Lepidoptera and Coleoptera, with an old English microscope, perhaps of Martin, and only partly achromatic. Since then I have used first-class microscopes of Ploesl, then those of Scheck (none of them is sufficient to show the transverse lines on the scales of Lepidoptera), later of Oberhauser and Nachet.

From this time almost every European naturalist gave up using microscopes mounted upon high stands, as observations with high objectives are more easily and accurately made in a sitting position, when the arms can be supported upon the table. The end is not attained by placing a microscope with a high stand upon a low table, because the hands are less readily guided at a distance from the eyes. The English opticians appreciated this, and arranged a strong wooden transverse rest for the hands, even in single microscopes.

I have noticed that foreign students entering the Institute for Pathological Anatomy, very soon exchange their high-stand English microscopes for short-stand instruments, and even here I was not surprised to see the Professor of Pathological Anatomy using a short-stand French microscope.

Doubtless every observer will handle his own instrument to greater advantage, but for certain purposes particular constructions are preferable; and indeed I know of no work that would actually require a high-stand microscope. I am the better able to judge, having examined microscopes of this kind in Germany and England, especially those of Fraunhofer, Ross, Smith, Amici, and others. It may be interesting to mention that Nobert's instruments are not considered superior. I have examined a first-class microscope with an objective fitted for correction, and calculated by him to have a power of 500 diameters. The marked yellow light in the Nobert microscopes is very trying to the eyes. The mechanical work is good, but not remarkable. A kind of screw for fine motion used by him is perhaps unknown. A long, strong, steel screw is used; the upper half of the thread of which is turned in the opposite direction from that on the under half, and the two halves differ somewhat in size. By this arrangement the motion of the screw moves the instrument only as far as the difference in the fineness of the two halves, and with a strong screw a very fine motion is obtained, and "dead point" is impossible.

The *Trichina spiralis* has singularly forwarded the manufacture of microscopes. Every physician and many other persons engaged in examining pork, tried to obtain a microscope as soon as possible. At first the manufacturers could not possibly meet the demand. Consequently the manufacture of these instruments has everywhere increased, and one can get a very good French or German student's microscope, amplifying 250 to 300 times, for twenty-five dollars. I have seen instruments with a power of 150 to 200 times for twenty dollars, or even less. The increasing number of instruments has been very advantageous to science, and I hope that the calamity of trichina, even now fearfully prevalent in Europe, will be compensated by a marked progress in science.

PROGRESS OF MICROSCOPICAL SCIENCE.

The Double Plate of Aulacodiscus oreganus.—From the proof-sheets of the Proceedings of the Boston Society of Natural Science which have reached us, we learn the following particulars of some communications on the above subject made to that Society in the course of this session by Mr. R. C. Greenleaf. Referring to the fact that Mr. Charles Stodder had already called attention to the double plate of the various disk forms among the diatoms, he mentioned that Mr. E. Samuels, in preparing a single specimen of *Aulacodiscus oreganus*, after placing it on the slide, found that it had divided, the upper shell slipping off from the under. This, he said, is the most perfect specimen of the division of this class of diatoms he had ever seen, and the most authentic, as the divisions really took place under the eye. This is a very interesting object, because it proves, if proof were needed, that these disks are formed of two shells, and thus conclusively reveals the fact that many species have been named by microscopists as new, that are only the thin under-layers of the shells of species already classified. Mr. Greenleaf is confident that many of the species named by Dr. Greville, although he was one of the most skilful and diligent of observers, are merely these thin shells removed from their connections. In the January number of the 'Quarterly Journal of Microscopical Science,' there is a figure given by Dr. Greville exactly like this under-shell, which he calls *Aulacodiscus orientalis*. Since writing the above remarks Mr. Greenleaf had seen a letter from Professor Eulenstein to Mr. Charles Stodder, in which he alludes to the paper of Dr. Greville on *Aulacodiscus orientalis*. Professor Eulenstein at first thought, as he did, that *A. orientalis* was the inner plate of *A. oreganus*, but after a more careful examination of the form, decided it was a new species. He had a slide containing the object. Mr. Greenleaf had only seen the drawing. Mr. Stodder is of the same opinion. He says that the granules in *A. orientalis* differ in form from those of *A. oreganus*, being square or oblong, and not arranged exactly in the same order. This last variation Mr. Greenleaf noticed in the drawing, but by a careful adjustment of the focus, the variation in this particular is small. Professor Eulenstein says there is a chance of error in examining these disk forms, in mistaking an immature frustule, separating from the parent, for the inner plate. Mr. Greenleaf would be inclined to hold to his first impression, but said he must defer to higher authority at present.

The Preservation of Sections of Brain and Spinal Cord.—Concerning Dr. Bastian's paper on this subject, which appeared in one of our earlier numbers, Mr. Alfred Sanders, M.R.C.S., has addressed the following letter to 'Scientific Opinion' (Nov. 24th):—

"Allow me to call the attention of those of your readers who are interested in microscopical investigations, to the use of creosote for this purpose: it was recommended by Dr. Ludwig Stieda, in Max

Schultze's *Archiv* for 1866, Bd. ii. Heft 4. I have tried it in comparison with Dr. Bastian's process, and find it at least equal, and, I may say, permanent, as I have sections of the brain of conger, made more than a year ago, which now show every nerve-fibre and cell in great perfection. Its manipulation is extremely easy, the brain, or other structure, being, as usual, hardened in chromic acid; the section is put for a short time in spirits of wine, and thence transferred to the creosote, which makes it transparent in a few minutes; it is then placed in Canada balsam. The balsam will mix easily with the creosote, or the solution in benzole may be employed. As Dr. Bastian did not mention this process in his paper above referred to, I presume that it is not generally known in England, which must be my apology for occupying your space with this communication."

The Anatomy of the Reproductive System.—In a paper read in June last before the Royal Académie of Vienna, Herr Gussenhauer described a new method he had devised for the microscopic study of these structures. It consisted in making a series of vertical sections, and it did not elicit any new points in structure. It is chiefly of interest from the fact that the author uses oil of cloves in preserving his specimens, and finds it answer very well.

The Homologies of the Polyzoa.—Mr. Alpheus Hyatt's paper on this subject, which was read in August before the American Association, is thus summarized:—The Embryology of the Hypocrepian Polyzoa shows that Loxosoma is the lowest of all in the order, and together with Pedicellina form the lowest suborder of the group. The progress of the whole order of Polyzoa is from this permanently invaginated form through intermediate stages to Cristatella, in which, when the polypide is inserted, even the stomach is carried up beyond the orifice of the cell. Thus the progress of structure is from an animal in which all the organs are crowded into the anterior end, into the cœnœcial system, and to one in which the cœnœcial or reproductive, evaginatory or gastric, and the lophoric or neural systems are all distinct when the animal is exserted. The Polyzoön may be transformed into a Brachiopod by simply enlarging the cœnœcial wall and carrying it over, enclosing the lophophore and reversing the position of the arms. Thus both the Polyzoa and the Brachiopods may be defined as sacs, closed at the posterior end by disks surrounded by tentacles, and perforated by an edentulous mouth, from which hangs the alimentary canal in the antero-posterior axis of the sac. The whole plan of the Mollusca was stated to be that of a simple sac, and the term Saccata proposed as more appropriate than that of Mollusca. The objection that the whole animal kingdom may be said to be sac-like has been raised. The Radiata are, it is true, radiated sacs, the Articulata ringed sacs, and the Vertebrata sacs divided by the vertebral axis, but the Saccata are typically sacs.

NOTES AND MEMORANDA.

New Cheap and Good Foreign Objectives.—It is alleged by Dr. Benecke that a young optician named Gundlach, of Berlin, has succeeded in making object-glasses, which are cheaper and more powerful than those of Hartnack and other opticians. His No. 7 is better than Hartnack's No. 9 or No. 10, at less than half the price of the No. 9. It has higher magnifying power, more light, and greater focal distance. Max Schultze says that Gundlach's No. 8 is better than Hartnack's No. 14, and is only a third of the price.

Mr. Moginie's New Strainer for Collecting-bottles.—In the notice of a New Strainer for Collecting-bottles, at page 286 in our last number, for Mr. Maginie, 37, Queen Square, *read* Mr. Moginie, 35, Queen Square, W.C. [The erratum occurred in the Report of the Old Change Microscopical Society.]

A Simple Form of Cell.—Mr. W. Beavan Lewis gives in 'Science Gossip' the following as an easy and effective method of making cells:—Purchase a box of endless elastic bands, and the addition of a jar of Brunswick black will now supply all the requisite material for the formation of a large stock of good and neat cells. Slip one of these bands on to the blades of a pair of scissors, slightly opening the latter to keep the band near the points, and prevent it from slipping off; now paint it over with a thin layer of Brunswick black, allow the band to fall flat on the centre of a glass slide, fix your object, and gently place your thin cover over it, which will firmly adhere to the band: this is cell No. 1. For cell No. 2 another band is slid on to the scissors after the first band has been painted; the pressure of a forceps will cause them to adhere, and now you have your cell double the depth of the first. The bands which I use are half an inch in diameter, and with these the deepest cell advisable to be made is that of three bands; should a deeper cell be required, bands of a larger diameter are necessary. I have a large number of objects mounted in this way, the majority being dry preparations, but I find this cell is equally serviceable for mounting in glycerine or Goadby's solution.

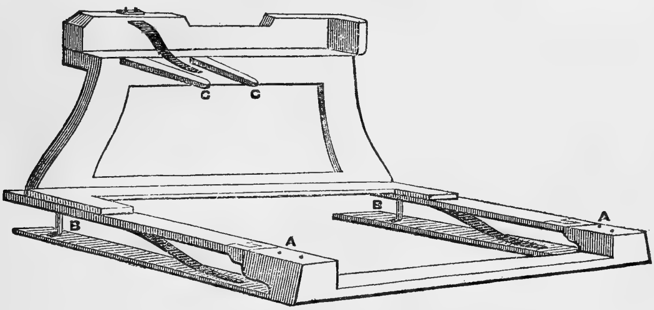
Dr. Lionel Beale on Protoplasm.—We understand that a second edition of this work is just about to be issued.

The Origin of Life.—Those who wish to see an able detailed and dispassionate review of the facts and arguments for and against Heterogeny, should consult a series of papers under the above title in the recent numbers of the 'British Medical Journal.' They are, we believe, from the pen of a distinguished Fellow of the Royal Microscopical Society.

Mr. Stephenson's New Safety Stage.—The following is a description of this ingenious contrivance, exhibited at the last meeting of the Royal Microscopical Society. The "Safety Stage" consists of a thin frame of brass, with thicker pieces screwed on at

the two front corners, to which is hinged at A A (Fig. 1) a second frame, also of thin brass, which supports the object or slide-holder.

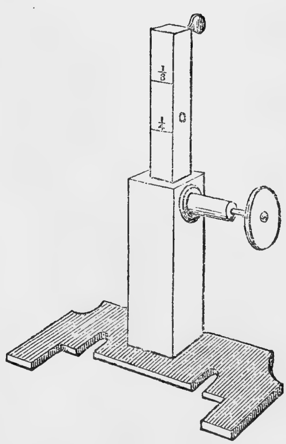
FIG. 1.



These frames are kept asunder at a distance of about $\frac{3}{16}$ths of an inch by light springs B B, which can be made so light as to carry as little beyond the weight of the stage as is wished — the hinges being so constructed as to keep the frames parallel, a result which is also effected or supported by the heads of two steady pins at the back of the stage.

The object is carried on the two arms C C, and is held in its place by a spring placed over and between them, this form having been adopted for greater facility in using the modes of illumination recently introduced by the President of the Microscopical Society, and by Messrs. Powell and Lealand; the former by the use of an equilateral prism, and the latter by a pencil of light from a small lens of short focus: the whole slides on to the present primary stage with a dovetail-piece.

FIG. 2.



In focussing down on an object placed on the safety stage, should the worker proceed too far, the upper part of the stage yields instantly to the pressure, and the object recedes. This should in itself be generally warning enough, but as it might not in all cases be deemed sufficient security, Mr. Stephenson has introduced a second and very simple instrument (Fig. 2) to act as a stop. This consists of a square rod of brass, marked on one face with lines, showing the height to which it must be adjusted to suit the various object-glasses used: it is held in its place by a pin passing through it, which is attached to a screw at the outer side of the socket in which the rod slides. This little instrument is placed, in

Ross's form, beneath the bar which carries the body of the microscope, and whilst permitting the front of the objective to touch the object on the stage, even to press it down by acting on the springs, will arrest all progress in this direction, before the upper part of the stage has been pressed upon the lower; thus, how careless soever a person may be, or however great may be the force used, the pressure on the object-glass, as on the thin cover of the object, is limited to the strength of the springs used, which may, as previously stated, be made as light as is desirable.

The want of such an arrangement is much felt by all persons using very high powers, and more particularly so now that the immersion system is coming more into vogue; and under this, we lose the benefit of the surface of the thin cover, as well as the dust, which, under the dry system, acts as a friendly beacon.

With the safety stage, not only will persons work with more confidence, but members of the Royal Microscopical and other Societies will be enabled to exhibit objects of interest under the highest powers, which they have hitherto in most cases been afraid to do.

CORRESPONDENCE.

Universal Mounting and Dissecting Microscope.

To the Editor of the 'Monthly Microscopical Journal.'

Birmingham, *November* 10, 1869.

Sir,—In a former number of the 'Microscopical Journal' (June), a description was given of a mounting and dissecting microscope that I had designed as a microscopist's companion, for enabling any one to carry in a single small case, whenever going into the country or to the seaside, a dissecting microscope with special arrangements for facilitating the mounting of objects; and a complete set of the apparatus and materials required for mounting, combined with a compound microscope good enough for ordinary requisites. This instrument has been referred to in a letter in a subsequent number of the Journal, in which there appears to have been a misapprehension in reference to the origin of the instrument.

In justice to the makers, Messrs. Field, of Birmingham, it should be stated that as regards the design of the case (the point specially referred to in the above letter), and the optical work, the whole credit is due to the makers so far as I am concerned, as the instrument was put into their hands to complete it in a portable and finished form. This object has certainly been ably and satisfactorily carried out by them, and they state that they are not aware of having derived any part of the idea from the writer of the above letter.

My original idea in the instrument was an endeavour to combine the advantages of Messrs. Beck's and Dr. Lawson's excellent dissecting microscopes, with a complete set of the apparatus and materials required in mounting objects; including the accessories of turn-table

and hot-plate, &c., which ordinarily occupy too much space to be compatible with great portability and compactness. A number of these instruments are now in use, and they are found very convenient for supplying a desideratum that I believe has not before been met; and they have been made very complete by improvements in the working-out of the details suggested by several microscopic friends.

William P. Marshall.

PROCEEDINGS OF SOCIETIES.*

Royal Microscopical Society.

King's College, *November* 10, 1869.

The Rev. J. B. Reade, F.R.S., President, in the chair.

The minutes of the previous meeting were read and confirmed.

A list of donations made to the Society was read, and a vote of thanks passed to the various donors. Special mention was made by Mr. Slack of a very interesting present to the Society by Dr. Millar, in the form of a fine specimen of an Amici reflecting microscope, the objectives of which were like miniature Newtonian telescopes. The present had acquired additional value by the gift on the part of the President of three powers adapted to the instrument.

A special vote of thanks was given to Dr. Millar and the President.

Mr. Slack also announced that Mr. Collins had presented to the Society an improved form (modified by Mr. Brooke) of his double nose-piece, the apparatus having been so constructed as to reduce the weight and lessen the price.

Mr. Slack exhibited on behalf of Mr. Blankley, F.R.M.S., a new polarizing apparatus devised by him, containing a sliding wedge of selenite working under a circular rotating-plate of the same material, and affording gradations of tint.

The President announced that Mr. Stevenson had brought for exhibition his new safety stage, which effectually protected the most delicate object-glasses and objects from injury. It consisted of a brass frame adjusted so as to allow the objective to come down just as far as the covering-glass of the object, but no farther. [For description and figures, *see* "Notes and Memoranda."]

A vote of thanks was passed to each of these gentlemen.

Mr. Hogg exhibited a new portable microscope by Mr. Collins, describing it as most convenient in form, and of very ingenious construction.

Dr. Pigott, who had intended to read his paper on "High Power Definition, with illustrative Examples," being unavoidably absent, the President requested Mr. Slack to read the communication. Mr. S. McIntyre having written a paper on a cognate subject, "The Scales

* Secretaries of Societies will greatly oblige us by writing out their reports legibly—especially the technical terms—and by "underlining" words, such as specific names, which must be printed in italics. They will thus ensure accuracy and enhance the value of their proceedings.—Ed. M. M. J.

of certain Insects of the order Thysanura," the President called upon Mr. McIntyre to read his communication before proceeding to the discussion.

Mr. J. Beck said the view his late brother held as to the structure of the *Podura* scale was that the markings were caused by wedge-shaped elevations running from the quill to the apex of the scale. He had himself paid great attention to the scales of Thysanuradæ, with a view to ascertain their structure. He hoped that microscopists would discontinue the use of the name "Podura" scale, as it involved great confusion, the apparent structure of the scales of different genera in them not being the same; and he hoped in speaking of the genera from which test-objects are taken that the scientific name of *Lepidocyrtus curvicollis* would be adopted. He thought that in order to ascertain the structure of the scales of this family, especially of those species possessing delicate scales, the structure of all must be taken into account, and assuming that the structure of all was similar in plan, determine whether the individual appearance was consistent with this idea. In *Lepisma saccharina* the appearance was undoubtedly due to corrugations on the one side running from the spine to the apex; to corrugations on the other side radiating from the spine to the circumference; this structure producing the appearance so familiar to observers. The correctness of this idea of the structure could be easily tested by running moisture on either side, as explained in his brother's work on the microscope. In *Petrobus maritimus* there was, as might be proved by experiment, the same structure with but slight variation, and the same might be said of *Macrotoma*, of which Mr. McIntyre had spoken. To ascertain whether the appearances in *Lepidocyrtus curvicollis* were consistent with the existence of lines, he had examined many butterfly scales having corrugations, and selecting those of the Peacock butterfly as the most suitable, found that where the scales overlapped one another at about an angle of 30° the lines were obliterated, and the "notes of exclamation" appeared. To resolve this object he considered almost as good a test as *L. curvicollis*. He thought there was *primâ facie* evidence that appearance on the test-scale was due to a like cause; but he had reason to modify his opinion, for observation had shown that the structure of the two sides of the scale was different. If a piece of glass be laid on the insect, the scales adhering would have their under-side uppermost, and if breathed upon while under the microscope, moisture would be seen to run up and down along corrugations, as in *L. saccharina* or *Petrobus;* but if this experiment be tried on the upper side of the scale the moisture would spread over the surface, and present the appearance of an undulating membrane. He inferred from this that the structure of *Lepidocyrtus* scale was similar to that of other genera in this group, slightly varying in the corrugated and undulating appearances; but still that in *Lepidocyrtus* as in *Lepisma*, the true structure on the under-side of scale is a series of corrugations on one side, and that the other side was slightly undulating, or nearly smooth; and that the "notes of exclamation" were due entirely to the refraction of light. This idea was confirmed by the appearance of the scale when the object-glass was out of focus.

Mr. Beck then alluded to the different views entertained by microscopists on the structure of the scale, and expressed his belief that if the Fellows would adopt the plan he had described they would agree with his conclusions.

Mr. Browning explained, in answer to an inquiry by the President, that Dr. Pigott had been kind enough to show him the markings he had observed, of which he (Mr. Browning) made a diagram. But beyond this he had been entirely ignorant of the contents of Dr. Pigott's paper until he had heard it read that evening. He thought it right to mention that Dr. Pigott had dispensed with a condenser, and illuminated the objects by the common lamp flame. Mr. Browning also said that the eye-piece used by Dr. Pigott was a very deep one, but he was not acquainted with its construction. He (Mr. Browning) remembered that in a discussion in which he took part with Sims, Dallmeyer, and Prichard, that they all agreed that the diffraction-rings of the stars to which allusion was made by Dr. Pigott were due to the undulations of light, but if the object-glass were well made no perceptible difference in the diffraction-rings would be remarked. In reply to a question from Mr. Slack as to whether it was not a fact that in the case of two telescope glasses, the one well corrected, the other having a considerable residue of spherical aberration, that the well-made glass would show the diffraction-rings clear and sharp, and in the other they would become intermingled and indistinct. Mr. Browning said that it was undoubtedly the case.

Mr. Hogg said he thought Dr. Pigott in error in what he had stated in regard to the marking on the *Podura* scale. He believed that Mr. R. Beck was nearer the truth in his view of the structure of the scale, especially as the experience of Mr. McIntyre confirmed his opinion. He (Mr. Hogg) had a great objection to the use of too deep an eye-piece, as it tended to increase errors; and he believed that this was one cause of the mistake into which Dr. Pigott had evidently fallen. He had also erred, he thought, in the method of illumination employed, for by using the direct flame of the lamp without any means of correcting the illuminating pencil, he would experience considerable disturbing power. He objected also to Dr. Pigott's mode of obtaining magnifying power by increasing the length of the body of the microscope. Moreover, it was well known that as age increased and presbyopia set in, the eye was often the subject of certain elements of visual disturbance. He thought some such disturbing element had led Dr. Pigott to believe that the appearances which he had represented were something entirely new. He (Mr. Hogg) had examined the scales with immersion lenses, and failed to discover anything at all resembling that which Dr. Pigott had described in his paper.

The President said he quite concurred in the observations made by Mr. Hogg, and he was only sorry that Dr. Pigott was not present to make a reply. He could not but feel (such was his confidence in the skill of the opticians of the day) that what he saw with their instruments was that which really existed, and that he had a clear and correct view of the objects under examination. With respect to *Podura* scale, he believed that Mr. Beck's description of the outline

was accurate, being what geologists would call the bluff-and-tail escarpment; and that the other portion under the spherules has a definite existence, as is proved by the beautiful observations of Mr. Wenham, who has shown that on a dark-ground illumination these little spherules appear like distinct and beautiful light circles, and this view of the object was entirely different to that usually seen by microscopists. He remembered that in 1837, just after Mr. Ross had constructed his first $\frac{1}{8}$th lens, he (the President) had shown him the *Podura* scale with dark-ground illumination, when Mr. Ross was greatly struck by the singular beauty of the view presented. By a little alteration in the obliquity of the light the small spines varied in colour, which led him (the President) to infer that they were small circles upon larger ones. It is evident, however, that instead of this there are two membranes with an elevation between them, which causes the hollow cone below the spherules. The surface of the scale is certainly corrugated, and he believed that smaller corrugations drawn by Dr. Pigott had led him to suppose that the surface was covered with beads. He should be glad to find that Dr. Pigott could confirm his own statements; in the meanwhile, however, in the presence of so many different opinions, he could only repeat the maxim, *Quot homines tot sententiæ.*

The meeting was adjourned until 8th December.

After the meeting was concluded Mr. McIntyre exhibited under the microscope the well-known test-scales of *Lepidocyrtus curvicollis* and *Degeria domestica*, and the following live specimens of the insect, *viz. Templetonia*, *Lepidocyrtus macrotoma*, and *Degeria Beckii.*

Donations to the Library and Cabinet from October 13th to November 10th, 1869:—

	From
Land and Water. Weekly	*Editor.*
Scientific Opinion. Weekly	*Editor.*
Society of Arts Journal. Weekly	*Society.*
Nature. Weekly	*Editor.*
The Student	*Publisher.*
Alcuni Cenni Sovra Studio dei Corpi Frangiati Delle Rane dei Professori G. B. Crivelli e Leopoldo Maggi	*Author.*
Intorno Alla Produzione del Leptothrix nota dei Professori G. B. Crivelli e L. Maggi	*Author.*
Sulla Produzione di Alcuni Organismi Inferiori in Presenza dell' Acido Fenico. Professori G. B. Crivelli e Leopoldo Maggi	*Author.*
Sulla Produzione del Bacterium Termo Duj. e del Vibrio Bacillus Duj. dei Professori G. B. Crivelli e L. Maggi	*Author.*
Sulla Derivazione del Bacterium Termo Duj. e del Vibrio Bacillus Duj. dai Granuli Vitellini dell' ovo di Pollo nota dei Professori G. B. Balsamo Crivelli e L. Maggi	*Author.*
The Chemical News. 6 Nos.	*W. T. Suffolk, Esq.*
Quarterly Journal of Geological Society	*Society.*
An Amici Reflecting Microscope by Cuthbert	*Dr. Millar.*
Four powers for the above	*The President.*
An improved Double Nose-piece	*Mr. C. Collins.*
Half-a-dozen Slides of Insects' Eggs	*Mr. J. T. Norman.*

WALTER W. REEVES,
Assist.-Secretary.

Old Change Microscopical Society.*

Oct. 29th, Nov. 5th, and 12th. The President, Charles J. Leaf, Esq., F.L.S., &c., in the chair.

Professor T. Rymer Jones continued his course of lectures on "Comparative Anatomy," his lectures on these evenings being upon the *Crustaceans* and *Entomostracans*.

November 19th.—In the unavoidable absence of the President, F. H. Leaf, Esq., presided. There was an attendance of about sixty members and visitors.

Mr. C. J. Richardson made some *extempore* observations on the Polyzoa, which were illustrated by the aid of diagrams and living specimens of *Plumatella repens* and *Fredicella sultana.*

Mr. H. Woodward, F.G.S. (of the British Museum), delivered a lecture on "Crabs, Lobsters, and Prawns." The lecturer's remarks included Fossil and recent families of Crustaceans, and were illustrated by numerous and beautiful diagrams and specimens.

The cordial thanks of the Society were awarded to Mr. C. J. Richardson and to Mr. H. Woodward, F.G.S., at the conclusion of their remarks.

The Secretary announced the following donations to the Society, and thanks were passed to the respective donors:—

	Donor.
The Universe	*The President.*
Collection of Sponges	*Mr. Chas. Tyler, F.L.S.*
Collection of Alpaca	*Mr. N. Burgess.*
Two Slides of Marine Polyps	*Mr. W. Carruthers, F.L.S.*
Journal of the Quekett Micro. Club	*The Club.*

A unanimous vote of thanks to the Chairman terminated the proceedings.

* Report supplied by Mr. S. Helm, F.R.M.S.

Note.—Reports of various Societies, though in type, are compelled through want of space to stand over till January.—Ed. M. M. J.

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Ueber eigenthümliche Zellen in der iris des Huhnes, von Herrn Hüttenbrenner. Wien. Gerold's Sohn.

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